SECTION 2 SYSTEM DESIGN

1 Supply systems and characteristics of the supply

1.1 Supply systems

1.1.1 The following distribution systems may be used:

a) on d.c. installations:
- two-wire insulated
- two-wire with negative earth

b) on a.c. installations:
- single-phase two-wire insulated
- single-phase two-wire with neutral earthed.
- three-phase three-wire with neutral insulated or directly earthed
- three-phase five-wire with neutral earthed, but without hull return (TN-S Type)
- three-phase four-wire with neutral earthed, but without hull return (TN-C Type)

1.1.2 The hull return system of distribution is not to be used for voltage greater than 50 Volts.

1.1.3 The requirement of [1.1.2] does not preclude under conditions approved by the Society the use of:

a) limited and locally earthed system, or

b) insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable conditions.

Note 1: Limited and locally earthed systems such as starting and ignition systems of internal combustion engines.

1.2 Recommended voltage

1.2.1 Recommended voltage for d.c. voltage systems are 12 V, 24 V and 48 V. Other voltages are to be considered by the Society on case by case basis.

1.2.2 The recommended values of nominal voltage, frequencies and maximum voltage permitted for a.c. yacht's service system of supply are given in Tab 1.

2 Sources of electrical power

2.1 Yachts less than 24 metres in length

2.1.1 For yachts whose length is less than 24 metres, requirements mentioned in [2.2] and [2.3] may be omitted.

Table 1 : AC voltages and frequencies for yacht's service system of supply

	Application	Recommended Nominal voltages V	Recommended Nominal Frequencies Hz	Maximum Voltage V
1	Power, cooking and heating			
	Equipment securely fixed and permanently connected	Single Phase 120/230 Three-Phase 400/440	Single/Three Phase 50/60	Single Phase 250 Three-Phase 1000
	Socket-outlet supplying equipment which is earthed	Single Phase 120/230	Single Phase 50/60	Single Phase 500
2	Fixed lighting and outlets intended for purposes not mentioned in items 1 and 3 but intended for apparatus with reinforced or double insulation or connected by a flexible cord or cable incorporating a protective conductor.	Single Phase 120/230	Single Phase 50/60	Single Phase 250
3	Socket outlets for use where extra precautions against shock are necessary:			
	a) supplied with or without the use of isolating transformers	Single Phase 24	Single Phase 50/60	Single Phase 55
	b) where a safety isolating transformer is used supplying one consuming device only. Both conductors of such systems should be insulated from earth.	Single Phase 120/230	Single Phase 50/60	Single Phase 250
	Note 1: The use of the nominal voltages as given in IEC 60092-201 is permitted			

2.1.2 Those yachts are to be fitted with a source of electrical power of sufficient capacity to supply all essential services necessary for their normal operation. The source of power may consist of generator(s) and/or batteries.

2.1.3 Where generator(s) are provided, they are to be capable of supplying the total load and simultaneously be capable of charging the batteries to 80% charge within 10 hours.

2.1.4 Where a.c. power is required it may be provided by one or a combination of the following to supply all yacht's services:

a) one or more shore-power connections

b) inverter supplying a.c. power from the yacht's d.c. system

c) on-board a.c. generator(s) supplying the required system load.

2.1.5 An a.c. generator may be driven by its own prime mover, or be powered from propulsion machinery, or be a shaft generator.

2.1.6 Where the main source of electrical power consists of a single a.c. generator, an alternative means of starting the generator is to be provided.

2.2 Main source of electrical power

2.2.1 A main source of electrical power is to be provided, of sufficient capacity to supply all electrical essential services necessary for maintaining the yacht in normal operational and habitable conditions without recourse to the emergency source of electrical power.

2.2.2 Where electrical energy is required for services necessary to the propulsion, navigation and safety of the yacht, the main source of electrical power is to consist of at least two generating sets. The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply all services necessary to provide normal operational conditions of propulsion and safety.

Such capacity is, in addition, to be sufficient to start the largest motor without causing any other motor to stop or having any adverse effect on other equipment in operation.

2.2.3 For yachts less than 500 gross tonnage, one of the generators may be driven by the propulsion machinery provided that electrical supply to the essential services is maintained regardless of the speed and direction of rotation of the main propulsion machinery or shafting.

2.2.4 For the purpose of calculating the necessary capacity, it is essential to consider which consumers can be expected to be in use simultaneously, in the various operational conditions of the yacht.

2.2.5 Electrical starting arrangements of generating sets are to have two separate storage batteries or may be supplied by two separate circuits from main engine storage batteries. In the case of a single auxiliary engine, one battery is acceptable. The combined capacity of the batteries is to be sufficient for at least three starts for each engine.

Provision is to be made to maintain the stored energy at all times.

2.3 Emergency source of electrical power

2.3.1 A self-contained emergency source of electrical power independent of the main source of power is to be provided.

For multihull yachts, where the main source of electrical power is located in two different hulls, each of which having its own self-contained power system, including power distribution and control systems, completely independent and so arrange that a fire or other casualty in any one hull will not affect the power distribution in the other, or to the services required in [2.3.5] or [2.3.6], the requirements of this section may be considered as satisfied without an additional emergency source of electrical power, provided there is at least in each hull one generating set of sufficient capacity to satisfy the requirement of [2.3.5] or [2.3.6].

2.3.2 The emergency source of power may be:

a) a generator set driven by an auxiliary engine with a fuel oil supply and a cooling system independent from the main engine

b) or a storage battery.

2.3.3 The emergency source of power and associated distribution switchboard is to be located above the uppermost continuous deck and is to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

When the above provision cannot be fulfilled, the emergency source of power may, with the agreement of the Society, be located under the uppermost continuous deck, in a room directly accessible from the main deck and protected with watertight and fire-resistant decks and bulkheads in accordance with Ch 4, Sec 4, [2].

2.3.4 In all cases the location of the emergency source of electrical power is to be such as to ensure that fire or other casualty in the space containing the main source of electrical power will not interfere with its continuous operation.

2.3.5 The emergency source of electrical power is to be capable of supplying simultaneously at least the following services for a period of 3 hours:

a) emergency lighting to assist escape from all enclosed spaces and to illuminate the disembarkation positions and over the sides

b) emergency lighting in the machinery spaces and navigation bridge

c) general emergency alarm system required in [3.10]

d) the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force and/or by the Flag Authority

e) the radiocommunication equipment required by the Flag Authority

f) the fire detection and fire alarm system

g) the control and alarm system of the fixed fire fighting system.

Note 1: Attention is drawn to compliance with possible national regulations.

2.3.6 For yachts of 500 gross tonnage and over the emergency source of electrical power is to be capable of supplying simultaneously for a period of 12 hours the following services in addition to those required in [2.3.5]:

a) shipborne navigational equipment required by the Flag Authority

b) the means of communication between the navigation bridge and the steering gear compartment

c) 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.

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

a) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage

b) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

c) immediately supplying at least those services specified in [2.3.5] or [2.3.6].

2.3.8 An indicator is to be mounted in a continuously manned control position, to indicate when the battery constituting the emergency source of electrical power is being discharged.

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

a) driven by a suitable prime mover with an independent supply of fuel, having a flash point (closed cup test) of not less than 43°C

b) started automatically upon failure of the main source of electrical power supply to the emergency switchboard and is to be automatically connected to the emergency switchboard

c) provided with a dedicated fuel oil supply tank fitted with a low level alarm, arranged at level ensuring sufficient fuel oil capacity for the emergency services for the period of time as required in [2.3.5] or [2.3.6].

2.3.10 For starting arrangements of emergency generating sets, following requirements apply:

a) Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to the Society is to be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets

b) Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by the Society 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, a second source of energy is to be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective.

c) Electrical starting systems is to be maintained from the emergency switchboard

d) 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.

2.3.11 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements, where provided.

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

3 Distribution

3.1 Earthed neutral systems

3.1.1 In earthed neutral systems, the source of power is directly connected to earth, and all exposed conductive parts of the installation are connected to the earthed point of the yacht's power system by protective conductor(s) or via the hull for steel yachts.

3.1.2 The neutral conductor is to be earthed only at the source of power (e.g. onboard generator, secondary of transformer).

When the yacht is connected to shore-power, the neutral is to be only grounded at the shore power source through the shore power cable.

3.1.3 System earthing is to be effected by means independent of the bonding arrangements of the non-current-carrying parts.

3.1.4 Earthed neutral systems are to be so designed that the potential earth fault current:

a) Does not exceed the design capacity of any part of the system

b) Is of sufficient magnitude to operate any protection.

Note 1: Where the neutral point is connected directly to earth, the earth loop impedance is to be low enough to permit the passage of current at least three times the fuse rating for fuse protected circuits or 1.5 times the tripping current of any circuit breaker used to protect the circuit.

3.2 Insulated systems

3.2.1 In insulated systems, the source of power is insulated from earth or connected to the earthed through a sufficiently high impedance.

3.2.2 Every insulated distribution system, whether primary or secondary (see Note 1), for power, heating or lighting, is to be provided with suitable means to monitor the insulation level to earth (i.e. the values of electrical insulation to earth).

Note 1: A primary system is one supplied directly by generators. Secondary systems are those supplied by transformers or convertors.

3.2.3 For yachts of 24 metres and over, the device required in [3.2.2] is to be capable of continuously monitoring the insulation level to earth and of giving an audible and visual indication of abnormally low insulation values.

3.2.4 In insulated systems, it is permissible for a single fault between a live part and an exposed conductive part to occur without automatic disconnection, provided that an earth monitoring device in compliance with [3.2.3] is fitted. A second fault is to result in automatic disconnection. A prospective touch voltage exceeding 50 V a.c. is not to persist for a time sufficient to cause a risk of harmful physiological effect in a person.

3.3 General requirements for distribution systems

3.3.1 For yachts of 24 metres and over, the power supply for essential services which are not duplicated is not to be disconnected by a single earth fault.

3.3.2 For yachts of 500 gross tonnage and over where the main source of electrical is necessary for propulsion and steering of the yacht, the system is to be so arranged that the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the yacht is maintained or immediately restored in the case of loss of any one of the generators in service.

3.4 A.c. distribution system

3.4.1 Where a.c. system is supplied by one or a combination of separate power sources (shore-power connection, generator or inverter), individual circuits are not to be capable of being energized by more than one source of electrical power at a time. The transfer from one power-source circuit to another is to be made by a means which opens all current-carrying conductors before closing the other source circuit, prevents arc-over between contacts and is interlocked by mechanical or electromechanical means. All current-carrying conductors are to be broken simultaneously when changing power source.

Note 1: Two or more three-phase generators, when properly synchronised are to be treated as one source.

3.4.2 The current consuming units are to be so grouped in the final circuits that the load on each phase, under normal conditions, are to be balanced as far as possible at the individual distribution and section boards as well as the main switchboard.

3.4.3 The continuity of supply is not to be impaired by load-produced harmonic distorsion or high load charges.

3.5 D.c. distribution system supplied from batteries

3.5.1 Each battery or group of batteries is to be capable of being isolated from the d.c. system which is supplied, normally by a switch in the positive conductor. Isolation switches are to be placed in a readily accessible location as closed as practical to the battery or group of batteries, but outside the battery compartment or container.

3.5.2 Remote controlled isolation switches are admitted providing they also permit safe manual control.

3.5.3 The following systems may be connected between the isolation switch and the battery:

a) electronic devices with protected memory and protective devices such as bilge pumps and alarms, if individually protected by a circuit breaker or fuse as close as practical to the battery terminal

b) ventilation exhaust blower of engine/fuel-tank compartment if separately protected by a fuse or circuit breaker as close as practical to the battery terminal

c) charging devices which are intended to be used when the yacht is unattended (e.g. solar panels) if individually protected by a fuse or circuit beaker as close as practical to the battery terminal.

3.5.4 The minimum continuous rating of the battery selection/isolation switch is to be at least equal to the maximum current for which the main circuit breaker is rated and also the intermittent load of the starter motor circuit, or the current rating of the feeder conductor, whichever is less.

3.5.5 For systems where both positive and negative conductors are isolated from earth, double pole switches are to be used.

3.6 Shore connection

3.6.1 Where a yacht requires to connect an a.c. supply from shore, a suitable shore supply inlet is to be installed on the yacht for the connection of the flexible cable(s) to the shore supply outlet socket.

3.6.2 The flexible shore power cable is to be provided with the following connecting arrangements:

a) a plug conforming to IEC 60309-2 to connect to the shore supply socket outlet and

b) a flexible cable in compliance with IEC 60245 or equivalent, permanently connected to the connection point on the yacht.

Note 1: For yacht whose length is less than 24 meters, connection point on board the yacht may be a plug receptacle conforming to IEC 60309-2.

3.6.3 Adequate means are to be provided to equalise the potential between the hull and the shore when the electrical installation of the yacht is supplied from shore.

3.6.4 The shore supply inlet is to be protected against overcurrent. The protective device is to simultaneously open all unearthed current carrying conductors and the neutral conductor. The earthing conductor required in [3.6.3] is not to be interrupted by operation of the overcurrent protection device.

3.6.5 The yacht's a.c. neutral is to be arranged to be earthed only at the shore supply when the shore supply is switched to supply the yacht's a.c. system (i.e. the yacht's a.c. neutral is to be disconnected from the yacht's earth when the shore power is connected).

3.6.6 For yachts which are fitted with an a.c. generation supplying onboard systems, an interlocked change-over switch is to be provided to prevent parallel connection between the shore power supply and the onboard generation. The change-over switch is to be of a type suitable for isolation and must include all phases and neutral.

3.6.7 The shore connection is to be provided with an indicator on the main switchboard in order to show when the cable is energised at the correct voltage.

3.6.8 Means are to be provided for checking the polarity or the phase sequence (for three-phase a.c.) of the incoming supply in relation to the yacht's system.

3.6.9 A permanently mounted waterproof warning sign is to be located at the intake point on the yacht giving full information on the system of supply, the nominal voltage and frequency of the yacht's system and the procedure for carrying out the connection. Information on the phase sequence for three phase a.c. systems is also to be given for three phase connections.

3.7 Supply of motors

3.7.1 A separate final circuit is to be provided for every motor required for an essential service and for every motor rated at 1 kW or more.

3.7.2 Each motor is to be provided with controlgear ensuring its satisfactory starting.

Direct on line starters are accepted if the voltage drop does not exceed 15% of the network voltage.

3.8 Power supply to lighting installations

3.8.1 Final circuits for lighting are not to supply appliances for heating and power. This requirement does not preclude the supply of cabin fans from lighting circuits.

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

3.8.3 Lighting fittings in the main engine rooms and public spaces of yachts of 24 metres and over are to be fed by at least two different circuits in such a way that a failure of any one circuit does not reduce the lighting to an insufficient level. One of these circuits may be supplied from the emergency source of power.

3.9 Navigation and signalling lights

3.9.1 Every yacht should be fitted with navigation lights in compliance with the requirements of the International Regulations for Preventing Collisions At Sea, 1972, as amended.

The construction and installation of navigation lights is to be to the satisfaction of the Appropriate Authority.

3.9.2 Navigation lights are to be connected separately to a dedicated distribution board placed in an accessible position on the yacht and directly supplied from the main source of power.

3.9.3 Each navigation light is to be controlled and protected in each insulated pole by a double-pole switch and a fuse or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board referred to in [3.9.2].

3.9.4 For yachts whose length is equal or exceeds 24 metres, the following additional requirements is to comply with.

a) Provision is to be made at position mentioned in [3.9.2] to connect the navigation lights distribution board to the emergency source of power by means of a changeover switch.

b) When it is not possible to visually observe the operation of the navigation lights from the yacht's deck, such lights are to be provided with an automatic indicator giving audible and/or visual warning in the event of failure of a navigation light.

   If a visual signal connected in series with the navigation light is used, means is to be provided to prevent the extinction of the navigation light due to the failure of the visual signal.

3.10 General emergency alarm system

3.10.1 Yachts of 24 metres and over are to be equipped with a system enabling the general broadcast of an alarm. This alarm may consist of the yacht's whistle or siren, provided it can be heard in all parts of the yacht.

3.10.2 For yachts of 500 gross tonnage and above the system required in [3.10.1] is to be supplemented by an electrically operated bell or klaxon system, powered from the main source of electrical power and also the emergency source of electrical power.

3.11 Specific requirements for special power services of yachts of 24 metres and over

3.11.1 The motors driving fans, fuel pumps and lubrication oil pumps are to be provided with remote control located outside the concerned rooms so that they can be stopped in the event of fire in the room where they are located.

3.11.2 The means provided for stopping the power ventilation of the machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

3.11.3 For the supply and characteristics of the distribution of the following services see requirements listed:

a) Fire extinguishing systems: Ch 4, Sec 10 as applicable

b) Fire detection systems: Ch 4, Sec 10, [6.1.2]

c) Steering gear: Ch 1, Sec 3, [2.3.2].

3.12 Main engine starting system

3.12.1 Yachts in which the only means of propulsion is an internal combustion engine with electric starting is to be provided with two batteries or group of batteries, each one of sufficient capacity for ensuring at least six consecutive start attempts of 10 seconds duration of the main propulsion engine.

3.12.2 One battery or group of batteries is to be reserved for the engine starting device, the other may be used for supplying the yacht's electrical services. Batteries used for supplying both starting system and other services are to be designed accordingly.

3.12.3 It is to be possible to select which battery or group of batteries is used for which service. Commutation between the two batteries or group of batteries is to be made via a fixed connection and selection switches placed in a readily accessible location, as close as practicable to the battery or group of batteries but outside the battery compartment or container.

Note 1: Service selection function may be combined with the isolation function required in [3.5.1].

3.12.4 For yachts with two main propulsion engines provided with electric starting device, each main engine is to be equipped with its own starting battery. Each battery is to be capable of being connected via a changeover switch and fixed cables to the starting system of the other main engine.

3.12.5 For yachts of 24 metres and over, arrangement of starting batteries is to be such that the batteries cannot be connected in parallel.

3.12.6 Provision is to be made to maintain the stored energy at all times.

3.13 Lightning protection

3.13.1 Lightning protection is to be provided as follows:

a) Non metallic hull yachts are to be provided with lightning conductor. The lower end of the lightning conductor is to be connected to an earthing plate of copper or other conducting material compatible with sea water, not less than 0.25m^2 in surface area, secured to the outside of the hull in an area reserved for this purpose and located below the water line so that it is immersed under all conditions of heel. The earthing plate for the lightning conductor is to be additional to, and separate from, the earthing plate required in Ch 2, Sec 4, [2.4.2]

b) In metallic hull yachts fitted with non-metallic masts, a lightning conductor is to be provided. The lower end of the lightning conductor is to be earthed to the hull

c) In metallic hull yachts, if there is electrical continuity between hull and lightning protective masts or other metallic superstructure of adequate height, no additional lightning protection is required.

Note 1: For yachts which are less than 24 meters in length, ISO 10134 may be used for guidance.

3.13.2 Lightning conductors are to be made of copper (strip or stranded) and are not to be less than 70 mm^2 in cross-section. They are to be secured to a copper spike not less than 12mm in diameter, projecting at least 300 mm above the top of the mast. The lower end of the conductor is to be earthed.

3.13.3 Lightning conductors are to be installed external to the yacht and should run as straight as possible. Sharp bends are to be avoided.

3.13.4 Only bolted, riveted or welded joints are to be used.

4 Degrees of protection of equipment and enclosures

4.1 General

4.1.1 Energized parts of electrical equipment are to be guarded against accidental contact by the use of enclosures. Access to energized parts of the electrical system is to require the use of hand tools or have a protection of at least IP2X. Depending on its location, electrical equipment is to have, as a minimum, the degree of protection specified in Tab 2.

4.1.2 In addition to the requirements of this paragraph, equipment installed in spaces with an explosion hazard is also subject to the provisions in [8.1.1]

4.1.3 Wherever possible, cable entries are to be positioned on the bottom of equipment and enclosures and are to have an IP rating equal to that of the equipment enclosure.

If location of cable entries on the sides or top of an enclosure is unavoidable, they are not to alter the IP of the equipment enclosure.

4.1.4 Socket outlets installed in locations subject to rain, spray or splashing (open deck) are to be able to be enclosed in IP 56 enclosures, as a minimum, when not in use. When the appropriate plug is connected the outlet is to maintain IP56.

4.1.5 Socket outlets installed in areas subject to flooding or momentary submersion are to be in IP67 enclosure, as a minimum, also maintaining IP67 when an appropriate plug is inserted.

Table 2 : Minimum required degrees of protection

Example of location	Switchboard and control gear	Generators	Motors	Transformers	Luminaires	Instrument	Switches	Accessories
Dry accommodation spaces Closed navigation bridge	IP 22	-	IP 22	IP 22	IP 22	IP22	IP 22	IP 22
Steering gear room (above floor) Control rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44
General store Provision rooms	-	-	IP 22	-	IP 44	-	IP 44	IP 44
Bathrooms and/or showers	-	-	-	-	IP 44	-	IP 55	IP 55
Engine (above floor) Damp or humid spaces Ventilation pipes	IP 44	IP 44	IP 44	-	IP 44	IP 44	IP 55	IP 55
Engine room (below floor)	-	-	IP X8	-	IP X8	IP X8	IP X8	-
Galleys and laundries	IP 44	-	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44
Open decks	IP 56	-	IP 56	-	IP 56	IP 56	IP 56	IP 56
Note 1: Electrical equipment is not to be installed below floor plates in engine rooms, except as indicated above.								

5 Diversity (demand) factors

5.1 General

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

5.1.2 Circuits supplying two or more final circuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity (demand) factor in accordance with [5.1.3] and [5.1.4].

Where spare-circuits are provided on a section or distribution board, an allowance for future increase in load is to be added to the total connected load, before the application of any diversity factor. The allowance is to be calculated on the assumption that each spare circuit requires not less than the average load on each of the active circuits of corresponding rating.

5.1.3 A diversity (demand) factor may be applied to the calculation of the cross-sectional area of conductors and to the rating of switchgear, provided that the demand conditions in a particular part of an installation are known or may reasonably be anticipated.

5.1.4 The diversity factor applied for motor power circuits is to be determined according to the circumstances. The normal full-load is to be determined on the basis of the name-plate rating.

6 Electrical protection

6.1 Protection against electric shock in systems with voltage exceeding 50 V a.c.

6.1.1 In both earthed neutral systems and insulated neutral systems, final circuits to locations in confined or exceptionally damp spaces where a risk of personal contact with live conductive parts may exist (e.g. socket outlets, lighting fittings) are to be fitted with a residual-current protective device with sensitivity of 30 mA maximum to automatically disconnect the supply in the event of a fault between a live part and an exposed non-current carrying conductive part.

Note 1: A residual-current protective device (RCD) is to provide a substantial degree of personnel protection in most circumstances in locations where the risk of accidental contact is increased. On yacht with relatively small single phase a.c. electrical installations powered intermittently from a shore supply, a single RCD protecting the whole of the yacht's a.c. system is commonly fitted. It should be noted that not every marina or boat yards have RCD protected shore power outlets as standards. The residual current device is to have a rated residual operating current not exceeding 30mA and an operating time not exceeding 40ms at a residual current of 150 mA.

6.2 Protection against overcurrent

6.2.1 Every circuit is to be protected against overload and short circuit by a fuse or circuit-breaker.

Note 1: An overcurrent is a current exceeding the nominal current.

Note 2: A short-circuit is the accidental connection by a relatively low resistance or impedance of two or more points in a circuit which are normally at different voltages.

Note 3: Overload is an operating condition in an electrically undamaged circuit which causes an overcurrent.

6.2.2 Selection, arrangement and performance of the various protective devices are to provide complete and coordinated automatic protection to ensure as far as possible:

- the continuity of service so as to maintain, through coordinated and discriminative action of the protective devices, the supply of circuits not directly affected by a fault
- elimination of the effect of faults to reduce damage to the system and the hazard of fire as far as possible.

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

6.2.4 Each overcurrent protective device is to be selected such that:

a) Its nominal current or current setting is not less than the design current of the circuit

b) Its nominal current or current setting does nor exceed the lowest current-carrying capacity of any of the conductors in the circuit

c) The overload current causing operation does not exceed 1.45 times the lowest current carrying capacity of any of the conductors of the circuit

d) The breaking and making capacity is to be in accordance with the prospective short circuit or earth fault current at the point at which the device is installed. If the breaking or making capacity is less, then the protective device is to be backed up by a fuse or circuit breaker in accordance with IEC 60092-202.

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

6.2.6 The use of fuses up to 320A for overload protection is permitted. When fuses are used, spare fuses are to be available onboard the yacht.

6.2.7 Circuit-breakers and fuses are to be of a type approved by Society in accordance with the appropriate IEC publications.

6.3 Localisation of protection

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

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

6.3.3 Overcurrent and fault current protective devices are not to interrupt protective conductors.

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

6.4 Protection of d.c. system

6.4.1 Each circuit being supplied by a battery is to be protected in the positive pole by a fuse or circuit-breaker located within 200mm of the battery terminals. If this is impractical, each conductor from the battery is to be contained within a protective covering, such as a sheathing conduit or cable trunking, for its entire length from the battery terminals to the circuit protective fuse or circuit-breaker. The following constitute exceptions:

a) The main power-feed cable from battery to an engine-cranking motor, if sheathed or supported to protect against abrasion and contact with conductive surfaces.

b) The main power-feed from the battery to the panel-board or switchboard, distribution panel or fuse block, if sheathed or supported to protect against abrasion and contact with conductive surfaces.

6.5 Protection of generators

6.5.1 DC or AC generators are to be protected against short-circuits and overloads by multipole circuit-breakers.

Note 1: The positive conductors of output circuits of self limiting DC generators and battery chargers not exceeding 2kW do not require fuses or circuit breakers.

6.5.2 For generators with a rated output equal or less than 50kVA which are not arranged to operate in parallel, a multipole switch with a fuse in each insulated phase on the generator side may be accepted.

Fuse rating is to be maximum 110% of the generator rated current and the trip of contactor is to be short-time delayed, with a maximum delay of 500ms.

6.5.3 Generators of more than 50kVA are to be provided with circuit-breaker in its output fitted with each of the following:

a) time delayed thermal overload protection (e.g 15 s)

b) short-time delayed short-circuit protection (e.g. 500 ms)

c) short-time delayed under voltage release (e.g. 500 ms).

Note 1: Thermal devices are not to be used for generator over-current protection.

Note 2: Undervoltage protection should trip the breaker if the voltage falls to 70%-35% of the rated voltage and prevent the closing of the circuit-breaker if the generator voltage does not reach a minimum of 85% of the rated voltage.

6.5.4 Generators intended for parallel operation are to be provided with reverse power protection. The tripping of the generator circuit-breaker is to be time delayed (e.g. 5s to 15s).

Note 1: Recommended value to be considered for the setting of the reverse-power protection: 8-15%.

6.5.5 For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in permanently attended space (e.g. navigation bridge).

6.5.6 For yachts of 500 gross tonnage and above, where the main source of electrical power is necessary for the propulsion of the yacht, load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.

Load shedding is to be automatic and should concern non-essential loads only.

An visual and audible alarm is to be activated at the navigation bridge in case of load shedding.

6.6 Protection of final circuits

6.6.1 Final circuits coming from distribution boards is to be protected against overload and short-circuit by multipole circuit breaker or switch and fuses on each non-earthed conductors.

6.6.2 The interrupting device may however be omitted if the outgoing circuit feeds another distribution board, or an apparatus located nearby (e.g. in the same compartment) and if an interrupting device is provided at the in-coming feeder of the distribution board.

6.6.3 In insulated system, final circuits for lighting are to be disconnected on both non-earthed conductors. Single pole switch may be used for circuits in dry accommodation spaces or circuits supplied at voltage not exceeding the safety voltage.

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

6.7 Protection of motors

6.7.1 Motors of rating exceeding 1 kW and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection may be provided by the same protective device for the motor and its supply cable (see [6.6.4]).

6.7.2 For motors intended for essential services, the overload protection may be replaced by an overload alarm (for steering gear motors see Ch 1, Sec 3, [2.3.5]).

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

6.7.4 The protective devices are to be adjusted so as to limit the maximum continuous current to a value within the range 105%-120% of the motor's rated full load current.

6.8 Protection of storage batteries

6.8.1 Batteries are to be protected against overload and short-circuit by means of fuses or multipole circuit-breakers placed as closed as practicable to the batteries but outside the battery compartment or container.

Overcurrent protection may be omitted for the circuit to the starting devices when the current drawn is so large that is impracticable to obtain short-circuit protection.

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

6.9 Special applications

6.9.1 Circuits which supply safety equipment, such as radio, navigation and navigational aids, are to be individually protected against short-circuits by means of circuit-breakers or fuses. These circuits are to be clearly identified.

6.10 Protection of measuring instruments, pilot lamps and control circuits

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

The protective devices are to be placed as near as possible to the tapping from the supply.

6.10.2 Control circuits and control transformers are to be protected against overload and short-circuit by means of multipole circuit-breakers or fuses on each pole not connected to earth.

Overload protection may be omitted for transformers with a rated current of less than 2 A on the secondary side.

The short-circuit protection on the secondary side may be omitted if the transformer is designed to sustain permanent short-circuit current.

6.11 Protection of transformers

6.11.1 The primary winding side of each power transformers is to be protected by a individual overload and short circuit device, rated at not more than 125% of the rated primary current of the transformer.

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

7 Electrical cables

7.1 General

7.1.1 Cables and insulated wiring are to be constructed in accordance with IEC Publications of the series 60092-3., and normally of a type approved by the Society.

Cable and insulated wires other than those specified in IEC Publications are subject to special consideration by the Society in each case.

7.1.2 All electrical cables and wiring external to equipment are to be at least of a flame-retardant type, in accordance with IEC Publication 60332-1.

7.1.3 In addition to the provisions of [7.1.2], when cables are laid in bunches, cable types are to be chosen in compliance with IEC Publication 60332-3 Category A.

7.1.4 Flexible cables constructed according to national standards are to be specially considered by the Society.

7.2 Conductors

7.2.1 Conductors are to be stranded and of annealed electrolytic copper according to IEC 60228. In yachts of aluminium construction, conductors are to conform to Class 2 upstream of transformers to avoid functioning as earth electrode.

7.3 Choice of protective covering

7.3.1 Cables fitted on decks exposed to the weather, in damp and wet locations (e.g. bathroom), in machinery spaces and wherever water condensation or harmful vapour (including oil vapour) may be present, are to have a water resistant sheath.

Note 1: Polyvinyl chloride (PVC), chlorosulphonated-polyethylene (CSP) and polychloroprene (PCP) sheaths are considered as water resistant in this context, although not suitable for permanent immersion in liquids. However such sheaths are to be avoided where they are likely to come into contact with and chemically react with polyurethane foam thermal insulating material.

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

7.3.3 In selecting the protective covering, due consideration is to be given to the mechanical strength required to withstand handling during installation and working conditions when in service.

If the mechanical strength of the protective covering is considered insufficient, the cables are to be mechanically protected (e.g. by an armour or by installation inside pipes or conduits).

7.3.4 PVC insulated cables are not to be used on decks exposed to the weather of yachts classed for unrestricted service.

7.4 Cables for submerged bilge pumps

7.4.1 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 armoured and is to be installed in continuous lengths from above the bulkhead to the motor terminals.

7.5 Internal wiring of switchboards and other enclosures for equipment

7.5.1 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 the Society.

7.6 Current carrying capacity of cables

7.6.1 The current carrying capacity for cables in continuous service, for various insulating materials are given in Table 3.

The values are based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

7.6.2 The current carrying capacity cited in [7.6.1] is applicable, with rough approximation, to all types of protective covering (e.g. both armoured and non-armoured cables).

7.6.3 When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Tab 4 may be applied to the current carrying capacity in Tab 3.

Table 3 : Current carrying capacity, for continuous service, in amps

Nominal Cross section, in mm²	Cable insulation											
	1 General purpose PVC			2 Heat resistant PVC			3 EPR and XLPE			4 Silicone rubber and mineral insulation		
	Temperature class 60°C			Temperature class 75°C			Temperature class 85°C			Temperature class 95°C		
	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores
1	8	7	6	13	11	9	16	14	11	20	17	14
1,5	12	10	8	17	15	12	20	17	14	24	20	17
2,5	17	15	12	24	20	17	28	24	20	32	27	22
4	22	19	16	32	27	22	38	32	27	42	36	29
6	29	25	20	41	35	29	48	41	34	55	47	39
10	40	34	28	57	49	40	67	57	47	75	64	53
16	54	46	38	76	65	53	90	77	63	100	85	70
25	71	60	50	100	85	70	120	102	84	135	115	95
35	87	74	61	125	106	88	145	123	102	165	140	116
50	105	89	74	150	128	105	180	153	126	200	170	140
70	135	115	95	190	162	133	225	191	158	255	217	179
95	165	140	116	230	196	161	275	234	193	310	264	217
120	190	162	133	270	230	190	320	272	224	360	306	252
150	220	187	154	310	264	217	365	310	256	410	349	287

Table 4 : 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

Table 5 : Correction factors for half-hour and one-hour service

Nominal cross-sectional area, in mm^2	Half-hour service	One-hour service
1 to 10	1.06	1.06
16	1.09	1.06
25	1.19	1.08
35	1.34	1.14
50	1.55	1.25

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

7.6.5 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 obtained from Tab 3 may be increased by applying the corresponding correction factors given in Tab 5.

In no case a period shorter than 1/2-hour is to be used, whatever the effective period of operation.

7.7 Minimum nominal cross-sectional area of conductors

7.7.1 In general the minimum allowable conductor cross-sectional areas are those given inTab 6.

7.7.2 The nominal cross-sectional area of the neutral conductor in three-phase distribution systems is to be equal to at least 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm^2. In such case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

7.7.3 For the nominal cross-sectional area of protective conductor, see Ch 2, Sec 4, [2.3.2].

7.8 Choice of cables

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

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

- the current carrying capacity is to be not less than the highest continuous load carried by the cable
- the voltage drop in the circuit, by full load on this circuit, is not to exceed the limits specified in [7.8.4] and [7.8.5].
- the cross-sectional area calculated on the basis of the above is to be such that the temperature increases which may be caused by overcurrents or starting transients do not damage the insulation.

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

Table 6 : 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 yacht or crew calls	0,2	0,1
Bus and data cables	0,2	0,1

7.8.4 For a.c. systems, when the conductors are carrying the maximum nominal service current, the voltage drop from the main or emergency switchboard busbars to any point in the installation is not to exceed 6% of the nominal voltage.

Note 1: The values for voltage drop specified in Ch 2, Sec 1, [5.2] apply under normal steady conditions. Under special conditions of short duration such as motor starting, higher voltage drops are permissible, provided that other equipment within the installation is capable of withstanding the effects of the higher voltage drop.

7.8.5 For d.c. systems supplied from batteries, the voltage drop to any point in the installation is not to exceed 10% of the nominal voltage.

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

For circuits to navigational equipment, communication equipment, windlass and engine starting the cross section areas are to be determined to restrict the voltage drop to the minimum specified by the equipment manufacturer.

Note 1: The voltage drop in d.c. conductor(s) between the generator(s) and the batteries is not to exceed 1% of the rated volatge during charging.

7.9 Parallel connection of cables

7.9.1 Cables with conductors of cross-section less than 10mm^2 are not to be connected in parallel.

Note 1: The current-carrying capacity of cables connected in parallel is the sum of the current ratings of all parallel conductors, provided that the cables have equal impedance, cross-section and rated conductor temperatures.

8 Electrical equipment for use in explosive atmospheres

8.1 General

8.1.1 Electrical equipment which is intended for use in explosive gas atmospheres or which is installed where flammable gases, vapours or explosive dusts are liable to accumulate, such as in spaces containing petrol-powered machinery, petrol fuel tank(s), or joint fitting(s) or other connection(s) between components of a petrol system, and in compartments or lockers containing LPG cylinders and/or pressure regulator, are to conform to the IEC 60079 series.

Note 1: For ships less than 24 metres in length ISO 8846, ISO 10239 and ISO 9094-1 and 2 may be applied.

8.2 Electrical equipment for vehicule spaces

8.2.1 For yachts with spaces carrying vehicles with fuel in their tanks for their own propulsion (e.g. jet-skis, motorcycles), electrical equipment located at less than 450 mm above the deck or within exhaust ventilation ducts is to be of a certified safe type. Refer to Ch 4, Sec 9.