

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Electrical installations in ships –
Part 507: Small vessels**

**Installations électriques à bord des navires –
Partie 507: Petits navires**

Withdrawn



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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

X

ICS 47.020.60

ISBN 2-8318-9499-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –**Part 507: Small vessels****FOREWORD**

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International Standard IEC 60092-507 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This second edition cancels and replaces the first edition published in 2000 and constitutes a technical revision.

This second edition includes the following significant technical changes with respect to the previous edition:

- a) DC, AC single phase, and AC 3-phase systems are now included in one document.
- b) The standard now specifies requirements for electrical installations relevant to all small commercial or leisure vessels up to 50 m or which have a Gross Registered Tonnage (GRT) not exceeding 500 GRT designed for use on inland waters or at sea.

The text of this standard is based on the following documents:

FDIS	Report on voting
18/1067/FDIS	18/1073/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts of the IEC 60092 series, published under the general title *Electrical installations in ships*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

Withdrawn

INTRODUCTION

This International Standard incorporates and coordinates, as far as possible, the existing requirements for electrical installations relevant to small vessels as published in other parts of the IEC 60092 series and the IEC 60364 series.

Withdrawn

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 507: Small vessels

1 Scope

This part of IEC 60092 specifies requirements for the design, construction and installation of electrical systems in small vessels, which have a length of up to 50 m, or which have a gross registered tonnage not exceeding 500 GRT, designed for use on inland waters or at sea. It is not intended to apply to small craft equipped with a battery supplying circuits for engine starting and navigation lighting only, recharged from an inboard or outboard engine driven alternator.

NOTE 1 For alternating current systems having voltages exceeding 250 V single-phase or 500 V three-phase, for direct current systems exceeding 50 V, and for vessels larger than 500 GRT or with a length greater than 50 m, other standards within the IEC 60092 series apply.

NOTE 2 Attention is drawn to regulations which govern specific requirements for navigation lights for small vessels.

NOTE 3 Attention is drawn to the fact that, in some countries the EC Directives covering EMC (89/336/EEC), low voltage (73/23/EEC) and general product safety (92/59/EEC) may be applied. In addition, Council Directive 97/70 applies to fishing vessels of 24 m in length and over, and Council Directive 98/18/EC applies to passenger ships. Attention is also drawn to the recreational craft directive 94/25/EC and 2003/44/EF. For high speed crafts, attention is drawn to the International code of safety for high-speed craft (HSC Code).

This standard applies to the following types of d.c. and a.c. electrical systems, individually or in combination:

- a) direct current system which operates at a nominal voltage not exceeding 50 V;

NOTE For example, for many small vessels, this will be the main electrical system. Alternatively, a vessel equipped with an a.c. system as its principal electrical system may be also equipped with a d.c. system for navigation and communications equipment supplied from batteries.

- b) single-phase alternating current system which operates at a nominal voltage not exceeding 250 V,

NOTE Such a system may be the principal electrical power system of a vessel or a system which may only be energized when connected to a shore supply. AC extra-low voltage, safety extra-low voltage, and other circuits may also comprise part of a single-phase a.c. system. A vessel may also be equipped with d.c. system(s) as in a) above.

- c) three-phase alternating current system which operates at a nominal voltage not exceeding 1 000 V.

NOTE The three-phase system is likely to be the principal electrical power system of a vessel's electrical installation. Such a vessel may also be equipped with single-phase a.c. subsystem(s) and d.c. subsystem(s).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60092-101:1994, *Electrical installations in ships – Part 101: Definitions and general requirements*

IEC 60092-201:1994, *Electrical installations in ships – Part 201: System design – General*

IEC 60092-202:1994, *Electrical installations in ships – Part 202: System design – Protection*

IEC 60092-301:1980, *Electrical installations in ships – Part 301: Equipment – Generators and motors*

IEC 60092-302, *Electrical installations in ships – Part 302: Low-voltage switchgear and controlgear assemblies*

IEC 60092-303, *Electrical installations in ships – Part 303: Equipment – Transformers for power and lighting*

IEC 60092-304, *Electrical installations in ships – Part 304: Semiconductor convertors*

IEC 60092-306, *Electrical installations in ships – Part 306: Equipment – Luminaires and accessories*

IEC 60092-307, *Electrical installations in ships – Part 307: Equipment – Heating and cooking appliances*

IEC 60092-350, *Electrical installations in ships – Part 350: Shipboard power cables – General construction and test requirements*

IEC 60092-352:2005, *Electrical installations in ships – Part 352: Choice and installation of electric cables*

IEC 60092-401, *Electrical installations in ships – Part 401: Installation and test of completed installation*

IEC 60092-502:1994¹⁾, *Electrical installations in ships – Part 502: Tankers – Special features*

IEC 60092-504:2001²⁾, *Electrical installations in ships – Part 504: Special features – Control and instrumentation*

IEC 60309-1, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

IEC 60309-2, *Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories*

IEC 60332-1 (all parts), *Tests on electric and optical fibre cables under fire conditions – Part 1: Test for vertical flame propagation for a single insulated wire or cable*

IEC 60332-3-22, *Tests on electric cables under fire conditions – Part 3-22: Test for vertical flame spread of vertically mounted bunched wires or cables – Category A*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility*

1) The fourth edition of IEC 60092-502 (1994) has been replaced by a new edition (IEC 60092-502:1999) which no longer contains the data referenced in Table 1 of this document.

2) The second edition of IEC 60092-504 (1994) has been replaced by a new edition (IEC 60092-504:2001) which no longer contains the data referenced in Table 1 of this document.

IEC 60898-1, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation*

IEC 60945, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 60947-7-1, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors*

ISO 8846, *Small craft – Electrical devices – Protection against ignition of surrounding flammable gases*

ISO 9094-1, *Small craft – Fire protection – Part 1: Craft with a hull length of up to and including 15 m*

ISO 9094-2, *Small craft – Fire protection – Part 2: Craft with a hull length of over 15 m*

ISO 10239, *Small craft – Liquefied petroleum gas (LPG) systems*

International Convention for the Safety of Life at Sea (SOLAS):1974
Amendment (1983)

3 Terms and definitions

For the purposes of this document, the terms and definitions given IEC 60092-101 (some of which are repeated here for convenience), as well as the following, apply.

3.1 General

3.1.1

safety voltage

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

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

NOTE 1 Consideration should be given to the reduction of the limit of 50 V under certain conditions, such as wet surroundings or exposure to heavy seas or where direct contact with live parts is involved.

NOTE 2 The voltage limit should not be exceeded either at full load or no load, but it is assumed, for the purpose of this definition, that any transformer or converter is operated at its rated supply voltage.

[IEC 60092-101, definition 1.3.19]

3.1.2

essential services

services essential for the navigation, steering or maneuvering of the ship, or for the safety of human life, or for special characteristics of the ship (for example, special services)

[IEC 60092-101, 1.3.4]

3.1.3

earthed

connected to the general mass of the hull of the ship in such a manner as will ensure at all times an immediate discharge of electrical energy without danger

NOTE 1 A conductor is said to be “solidly earthed” when it is electrically connected to the hull without a fuse-link, switch, circuit-breaker, resistor, or impedance, in the earth connection.

NOTE 2 In the USA, “grounded” is used instead of “earthed”.

[IEC 60092-101, 1.3.9]

3.1.4

engine negative terminal

terminal on the engine to which the negative cable of a battery system is connected

3.2 DC systems of distribution

3.2.1

two-wire d.c. system

d.c. system comprising two conductors only, between which the load is connected

[IEC 60092-201, 2.2.1]

3.3 AC systems of distribution

3.3.1

single-phase two-wire a.c. system

single-phase a.c. system comprising two conductors only, between which the load is connected

[IEC 60092-201, 2.3.1]

3.3.2

single-phase three-wire a.c. system

single-phase a.c. system comprising two conductors and a neutral wire, the supply being taken from the two outer conductors or from the neutral wire and either outer conductor, the neutral wire carrying only the difference-current

[IEC 60092-201, 2.3.2]

3.3.3

three-phase three-wire system

system comprising three conductors connected to a three-phase supply

[IEC 60092-201, 2.3.3]

3.3.4

three-phase four-wire system

system comprising four conductors of which three are connected to a three-phase supply and the fourth to a neutral point in the source of supply

[IEC 60092-201, 2.3.4]

3.4 Protection

3.4.1

final circuit

that portion of a wiring system extending beyond the final overcurrent protection device for that circuit

[IEC 60092-101, 1.3.17, modified]

3.4.2

overcurrent protection device

device, such as a fuse or circuit-breaker, designed to interrupt the circuit when the current flow exceeds a predetermined value for a predetermined time.

3.4.3

fuse

device that by the fusing of one or more of its specifically designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device

3.4.4

circuit-breaker

mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions, and also making, carrying for a specified time and breaking currents under specified abnormal conditions such as those of a short circuit

3.4.5

residual (differential) current device (RCD) /ground-fault circuit interrupter (GFCI)

mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

3.4.6

low-voltage switchgear and controlgear

combination of one or more low-voltage switching devices together with associated control, measuring, signaling, protective, regulating equipment etc. often contained within an enclosure or mounted on a panel

NOTE Examples of devices are circuit-breakers, fuses, switches, instruments and indicators.

3.4.7

protective conductor

conductor provided for purposes of safety, for example, protection against electric shock by electrically connecting any of the exposed and extraneous conductive-parts of electrical equipment of a vessel with non-metallic hull to the vessel's main earth

NOTE In the case of a vessel with metallic hull, exposed and extraneous conductive parts may be bonded to the ship's hull by permanent and reliable metal to metal joints of negligible impedance.

[IEV 195-02-09, modified]

3.4.8

bond

connection of non-current-carrying parts to ensure continuity of electrical connection, or to equalize the potential between parts comprising, for example, the armour or lead sheath of adjacent length of cable, the bulkhead, etc. For example, bulkhead and cables in a radio-receiving room

[IEC 60092-101, 1.3.7]

3.4.9

neutral conductor

conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

[IEV 195-02-06]

3.4.10**sheath**

uniform and continuous tubular covering of metallic or non-metallic material, generally extruded

[IEV 151-12-41, modified]

3.5 Equipment**3.5.1****cable trunking**

system of enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables or cords and for the accommodation of other electrical equipment

[IEV 442-02-34, modified]

3.5.2**accessible (as applied to equipment)**

an object or device that can be inadvertently touched or approached nearer than a safe distance by any person. It is applied to objects not suitably guarded or insulated

[IEC 60092-101, 1.3.5]

3.5.3**captive-spade terminal**

conductor terminal component which is maintained in connection to the screw or stud even when the threaded terminal fastener is loose

3.5.4**certified safe type equipment**

equipment designed and constructed to comply with IEC 60079 series

3.5.5**shore-power socket inlet**

fitting designed for mounting on a vessel, of a shrouded male type, to connect to the female connector on the vessel end of the shore-power cable, in order to make the electrical connection for transmission of electrical energy

3.5.6**transformer**

transformer with isolating separation between the input and output windings and the protective conductor

3.5.7**generator**

device which creates d.c. or a.c. (alternator) power for distribution to the electrical system on board a vessel.

NOTE In its simplest form a generator may be an engine-driven alternator with integral rectifier for recharging a small vessel's extra-low voltage system. It may also be a solar panel, generator driven by wind or water mill or fuel cell.

[IEV 411-32-01, modified]

3.5.8 battery

3.5.8.1 vented cell

cell which allows products of electrolysis and evaporation to escape freely from the cells to the atmosphere and can receive additions to the electrolyte

3.5.8.2 sealed cell

cell which remains closed and does not release or take in gas or liquid when operated within the limits specified by the manufacturer (the cells may be equipped with a safety device to prevent dangerously high internal pressure)

3.5.8.3 valve regulated battery

cells which are closed but have a valve which allows the escape of gas if the internal pressure exceeds a predetermined value (the lead acid version is called the valve-regulated lead-acid VRLA)

4 General requirements

4.1 Ratings

Conductors, switchgear and accessories shall be suitable for expected environmental and operational conditions and shall sustain anticipated overloads and transient current induced by motor start-up without damage, tripping or overheating.

4.2 Ambient air and cooling water temperature

Electrical equipment shall be designed to operate satisfactorily under the various temperature parameters indicated in Table 1 (from Table 4 of IEC 60092-101).

Table 1 – Design parameters – Temperature

Parameters		Unit value	Type of equipment
Relevant IEC standard	(Sub)clause		
High air temperature		° C	
IEC 60092-201	Clause 33	45	Cables
IEC 60092-301	3.1 (Table A.1)	50	Generators and motors
IEC 60092-352	3.3.4	45	Cables
IEC 60092-502:1994	A.2.1.3, A.3.1.3, A.3.2.3.3	50	Certified safe-type equipment (for use in tankers)
IEC 60092-504:1994	3.2	55	Control and instrumentation
Low air temperature		° C	
		5	General
		– 25	Open deck
High water temperature		° C	
IEC 60092-301	3.1 (Table A.1)	30	Generators and motors

4.3 Inclination of vessel

Electrical equipment shall be designed to continue to operate satisfactorily with the vessel at the inclinations from normal indicated in Table 2 (from Table 6 of IEC 60092-101).

NOTE For sailing vessels only, maximum heel angles of 45° on either tack should be considered.

Table 2 – Angular deviation and motion

	Angular deviation about fore-and-aft axis (list)	
	General conditions ^{a,b}	± 15°
Static condition	Emergency conditions	± 22° 30'
	Angular deviation about athwartship axis (trim)	
	Emergency conditions ^a	± 10°
	Rotation about fore-and-aft axis (rolling) ^c	± 22° 30'
Dynamic condition	Rotation about athwartship axis (pitching) ^c	± 7° 30'
	^a The vessel in any combination of angles within these limits. ^b For ships for the carriage in bulk of liquefied gases and dangerous chemicals, refer to the 1983 Amendment to SOLAS 1974, Volumes II and III. ^c These motions may occur simultaneously.	

4.4 Voltage and frequency variations

Equipment shall function under the normal voltage and frequency variations and harmonic distortion which can occur in the distribution system in normal operation.

4.4.1 DC systems

The nominal d.c. voltage tolerance at the battery terminals over which all d.c. equipment shall operate is ± 10 %.

The essential services of the vessel shall remain functional to the minimum voltage at the battery terminals.

NOTE When battery chargers/battery combination are used as d.c. power systems, adequate measures should be taken to keep the voltage within the specified limits during charging, quick charging and discharging of the battery.

4.4.2 AC systems

The system shall be designed to operate within the following limits:

- i) frequency: ± 5 %;
- ii) voltage: $\begin{matrix} + 6 \\ - 10 \end{matrix}$ %;
- iii) single harmonic distortion: < 3 %;
- iv) total harmonic distortion: < 5 %.

Table 3 gives recommended values of nominal voltage and frequencies as well as the maximum voltages permitted for a vessel's service systems of supply.

Table 3 – AC voltages and frequencies for vessel's service systems of supply

Application		Recommended nominal voltages	Recommended nominal frequencies	Maximum voltage
		V	Hz	V
1	Power, cooking and heating. Equipment securely fixed and permanently connected	Single-phase 120/230	Single-phase/Three-phase 50 or 60	Single-phase 250
		Three-phase 400/440		Three-phase 1 000
	Socket-outlet supplying equipment which is earthed	Single-phase 120/230	Single-phase 50 or 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 or 60	Single-phase 250
3	Socket-outlets for use where extra precautions against shock are necessary:			
	a) supplies with or without the use of isolating transformers	Single-phase 24	Single-phase 50 or 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	120/230	50 or 60	250
NOTE The use of the nominal voltages as given in IEC 60092-201 is permitted.				

4.5 Electrical power sources

The vessel's electrical power may be supplied by a generator(s) and/or main battery bank having sufficient capacity to supply the essential services.

4.5.1 DC systems supplied from batteries

A vessel in which the only means of propulsion is an internal combustion engine with electric starting shall be provided with two batteries or group of batteries, each one of sufficient capacity to start the engine.

One battery or battery group shall be reserved for engine starting service, the other for supplying the vessel's electrical services. It shall be possible to select which battery or group is used for which service and also to connect both battery groups in parallel in an emergency to assist engine starting. Special charge splitting arrangements may also be fitted if required to enable two or more batteries to be re-charged by a single generator.

Each main battery bank shall be capable of being isolated from the d.c. system which is supplied, normally by a switch in the positive conductor from each battery or group of batteries. The isolator switch function may be combined with the service selection function above. The battery selector switch or control shall be fitted in a readily accessible location, as close as practical to the battery or group of batteries.

Isolation switches shall not be placed in battery compartments or containers. Remote-controlled isolation switches, if used, shall also permit safe manual operation.

The following systems, however, 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 vessel is unattended (for example, solar panels, wind generators) if individually protected by a fuse or circuit-breaker as close as practical to the battery terminal.

The minimum continuous rating of the battery selection/isolation switch shall 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. A separate battery-disconnect switch may be installed for the engine-cranking motor circuit.

4.5.2 DC generator

These are generally alternators with integral rectifiers and regulators fitted to the propulsion machinery which charge accumulator batteries supplying the vessel's electrical equipment and essential services.

The generator(s) shall be capable of supplying the total load and simultaneously be capable of charging the main battery bank to 80 % charge within 10 h.

Wind-driven d.c. generators, towed impeller-driven generators and photo-voltaic systems shall be fitted with charge regulators set so that the gassing voltage of the battery to which they are connected is not exceeded

4.5.3 AC systems

Power may be provided by one or a combination of the following to supply the required design-system load:

- a) one or more shore-power cables per vessel, and associated power inlets, wiring and components with a capacity to supply the required design-system load;
- b) inverter supplying a.c. power from the vessel's d.c. system;
- c) on-board a.c. generator(s) supplying the required system load;
- d) combination of shore-power cable(s) and on-board generator(s) used simultaneously if the vessel's circuitry is arranged in such a way that the load connected to each source is isolated from the other.

Individual circuits shall not be capable of being energized by more than one source of electrical power at a time. Two or more three-phase generators, when properly synchronized, shall be treated as one source. Each shore-power inlet, generator or inverter shall be considered a separate source of a.c. electrical power. The transfer from one power-source circuit to another shall 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 shall be broken simultaneously when changing power sources.

4.5.4 AC generator

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

Where an a.c. system is provided as a main source of electric power and consists of a single generator, an alternative means of starting the generator shall be provided.

Electrical machines, including shaft generators and/or static converters/inverters shall comply with the relevant requirements of IEC 60092-301 and IEC 60092-304.

The power-feeder conductors from a generator shall be adequate for the thermal capacity of the generator and shall be protected at the generator with overcurrent protection devices in accordance with the requirements of IEC 60092-202.

NOTE An exception may be made for self-limiting (self-adjusting) generators whose maximum overload current does not exceed 120 % of its rated current output; these do not require additional external overcurrent protection.

The continuity of supply should not be impaired by load-produced harmonic distortion or high load charges.

The combined prime mover, transmission system and generator shall be designed to withstand without damage the effects of the most onerous short-circuit condition at the generator terminals when running at rated voltage and speed.

Where synchronization and parallel operation of several generators is required, then the relevant sections of other standards within the IEC 60092 series apply.

4.5.5 Measuring instruments

Normal full load values shall be marked in red on the instrument scale for all indicating instruments and appropriate labels shall be fixed to digital instruments when employed.

4.5.5.1 Instruments for batteries

Main battery banks shall be provided with at least one voltmeter, switchable between each group, and an ammeter. Alternatively, proprietary battery condition monitoring devices may be fitted to the monitor and display the state of the battery(s).

4.5.5.2 Instruments for d.c. generators

A d.c. generator with an output of 2 kW or more, which is not operated in parallel, shall be provided with at least one voltmeter and one ammeter.

Generators for parallel operation shall be provided with one voltmeter for each generator (or one voltmeter and a changeover for its connection to each generator), one ammeter for each generator and one voltmeter for each section of busbar.

For compound-wound generators fitted with equalizer connections, the ammeter shall be connected to the pole opposite to that connected to the series winding of the generator.

4.5.5.3 Instruments for a.c. generators

An a.c. generator not operated in parallel, except single-phase generators smaller than 2 kVA, shall be provided with at least one voltmeter and an ammeter in each phase (or one ammeter with a selector switch which enables it to measure the current in each phase). Generators greater than 15 kVA shall be provided with a frequency meter.

Generators for parallel operation shall be provided with a wattmeter and an ammeter in each phase conductor (or one ammeter with a selector switch to permit the measurement of current in each phase). Wattmeters shall be capable of indicating reverse power up to 15 % of the rated full load of the generator. Two voltmeters, two frequency meters and a synchronizing device comprising either a synchroscope and lamps, or an equivalent arrangement, shall be provided for paralleling purposes. One voltmeter and one frequency meter shall be connected to the busbars; the other voltmeter and frequency meter shall have a selector switch to permit measurement of the voltage and frequency of any generator.

NOTE When generators are run in parallel in installations with the neutral earthed, it is necessary to ensure that the equalizing current caused by harmonics does not exceed harmful values. Reference should be made to guidance from the generator manufacturer.

4.6 Equipment

4.6.1 Transformers

Transformers used for power, lighting and as static converters, starting transformers, static balancers, saturable reactors and transductors, including single-phase transformers rated at less than 1 kVA, and three-phase transformers rated at less than 5 kVA, shall comply with IEC 60092-303.

Transformers shall be installed in well-ventilated locations. Their connections should be protected against such mechanical damage, condensation and corrosion as may be reasonably expected.

Transformers with liquids containing polychlorinated biphenyls (PCBs) are not to be used.

4.6.2 Converters/inverters

Converters/inverters shall be installed so that the circulation of air around them is not impeded, and so that the air temperature at their cooling inlet does not exceed the ambient temperature.

Natural air-cooling units should be designed with sufficient ventilation openings or with sufficient cooling surface to radiate the heat so that totally enclosed equipment will operate within the design temperature limits.

Converters/inverters shall not be mounted near sources of heat such as engine exhaust pipes.

Converter/inverter components shall be so constructed that they can be removed without dismantling the complete unit.

4.7 Electrical equipment and enclosures

4.7.1 General requirements

Ventilation shall be adequate to maintain the ambient temperature at or below the maximum at which the equipment is designed to operate. Enclosures for electrical equipment shall be mechanically strong and rigid, and mounted so that the equipment will not be affected by the distortion, vibration or movement of the vessel's structure that occur during normal operation of the vessel. Switchgear and controlgear assemblies shall be in accordance with IEC 60092-302.

4.7.2 General degree of protection of equipment and enclosures

Energized parts of electrical equipment shall be guarded against accidental contact by the use of enclosures. Access to energized parts of the electrical system shall require the use of hand tools or have a protection of at least IP 2X. Depending on the location, electrical equipment shall, as a minimum, have the degree of protection shown in Table 4.

Table 4 – Degree of protection in accordance with IEC 60529

Example of location	Generators	Motors	Trans-formers	Switch-board and control-gear	Instruments	Switches	Luminaires	Access-ories
Steering gear room (above floor) and control rooms	IP22	IP22	IP22	IP22	IP22	IP22	IP22	IP44
Battery rooms							IP44+(Ex)	
General store; provision room		IP22				IP44	IP44	IP44
Closed navigation bridge; accommodation spaces		IP20	IP20	IP20	IP20	IP20	IP20	IP20
Damp or humid spaces; ventilation pipes and engine room (above floor)	IP44	IP44	IP44	IP44	IP44	IP55	IP44	IP55
Engine room ^a Steering Gear (below floor)		IPX8			IPX8	IPX8	IPX8	
Open deck		IP56		IP56	IP56	IP56	IP56	IP56
^a Electrical equipment shall not be installed below floor plates in engine rooms, except as indicated above.								

4.7.3 Protection from dripping water

Where necessary, electrical equipment with a degree of protection less than IPX2 shall be provided with a canopy or other suitable means to protect the current-carrying parts and the insulation from dripping water.

4.7.4 Cable entry

Cable entries shall, wherever possible, be positioned on the bottom of equipment and enclosures and shall have an IP rating equal to that of the equipment enclosure.

If cable entries are located on the sides or top of an enclosure, they shall not alter the IP degree of the equipment enclosure.

4.7.5 Identification

All electrical equipment and enclosures shall be marked with

- manufacturer;
- model number or designation;
- electrical rating in volts and amperes or volts and watts;
- phase and frequency, if applicable;
- certified safe type, if applicable.

4.7.6 Segregation of d.c. and a.c. systems

Vessels equipped with both d.c. and a.c. electrical systems shall have the d.c. and a.c. distribution from either separate distribution boards, or from a common distribution board with a partition to separate the a.c. and d.c. sections from each other.

4.7.7 Busbars

Busbars and their connections shall be made of copper and shall be designed to withstand mechanical stresses due to short circuit. The maximum temperature rise shall be 45 °C.

Bare busbars shall comply with the minimum clearances and creepage distances given in Table 5.

Table 5 – Minimum clearances and creepage distances for bare busbars

Rated insulation voltage V	Minimum clearance mm	Minimum creepage distance mm
≤ 250	15	20
> 250 to < 690	20	25
> 690 to < 1000	25	35

4.7.8 Switches and controls

Each switch or control shall be marked to indicate its use, unless the purpose of the switch is obvious and its mistaken operation will not cause a hazardous condition. Switching devices shall be so designed and arranged that when in the off position they cannot accidentally move sufficiently to close the circuit.

4.7.9 Final circuits

Final circuits may be supplied from individual distribution boards or panels, or from distribution sections of switchboards.

Protective devices such as circuit-breakers or fuses shall be provided at the origin of each final circuit to interrupt any overload current in the circuit conductors before heat can damage the conductor insulation, connections or wiring-system terminals. The selection, arrangement and performance characteristics should be such that the following is achieved:

- maximum continuity of service to healthy circuits under fault conditions through selective operation of the various protective devices;
- protection of electrical equipment and circuits from damage due to overcurrents, by coordination of the electrical characteristics of the circuit or apparatus and the tripping characteristics of the protective devices. For every fuse and circuit-breaker there shall be provided adjacent to it an indication of its intended nominal current appropriate to the circuit it protects. The owners manual shall include an electrical schematic diagram detailing each fuse and circuit breaker in the vessel's electrical system together with the nominal current of the circuit which each fuse and circuit breaker protects.

4.8 Plugs and socket-outlets

4.8.1 AC system

Where an earthed system is used, plug and socket-outlets of the earthing type shall be arranged with a terminal provided for the protective conductor.

Where socket-outlets are supplied at different voltages, the socket-outlets and plugs shall be designed in such a way that an incorrect connection cannot be made.

4.8.2 DC systems

Socket-outlets and matching plugs used in d.c. systems shall be different from and not be interchangeable with those used in the a.c. system on the vessel.

4.8.3 Installation in special locations

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

Socket-outlets installed in areas subject to flooding or momentary submersion shall be in IP 67 enclosures, as a minimum, also maintaining IP 67 when an appropriate plug is inserted.

Socket-outlets provided for the galley area shall be located so that appliance cords may be plugged in without crossing above a galley stove or sink or across a traffic area.

4.9 Battery installation

4.9.1 General arrangements

Batteries shall be secured against movements and inclinations occurring during small vessel use and shall be protected against falling objects. At inclinations up to 45°, electrolyte from vented cells shall not leak. On sailing vessels, batteries shall be secured sufficiently to prevent them from breaking free in the event of a complete capsize (i.e. inversion). Lead-acid storage batteries and alkaline storage batteries shall not be placed in a common cabinet or container or in close vicinity to each other.

Where batteries, except for valve-regulated types, are fitted in a machinery space, drip trays or containers resistant to the effects of the electrolyte shall be provided. Batteries shall not be installed directly above or below a fuel tank or fuel filter and any other metallic component of the fuel system within 300 mm above the battery top, as installed, shall be electrically insulated.

4.9.2 Ventilation

The machinery space in which lead-acid storage or alkaline storage batteries are placed shall be well ventilated to free air so that hydrogen and oxygen cannot accumulate.

Where batteries are installed in a separate closed compartment or containers reserved for batteries, a vent system or other means shall be provided to permit the discharge from the vessel of gasses released by battery during charge.

The air inlet to battery compartments or containers shall be below the level of the battery, and the outlet shall be at the highest point of the compartment or container and shall lead directly to the open air with bends of no more than 45°.

The minimum rate of ventilation (q) in litres per hour (l/h) shall be as given by the following formula:

$$q = 110 \times I \times n$$

where

n is the number of cells in series;

I is the current in amperes, selected from Table 6.

Table 6 – Reference currents for calculation of minimum ventilation

Battery type	Vented lead-acid ("Wet")		Valve-regulated lead-acid (VRLA)		Vented NiCd	
	Note 1					
Maximum charging voltage Volts per cell (VPC)	2,23	2,4	2,27	2,4	1,4	1,55
Current <i>I</i> per 100 Ah nominal capacity Amperes (A)	0,5	2,0	0,1	0,8	0,5	5
NOTE 1 Low maintenance with Sb <3 %.						
NOTE 2 Further reference may be made to appropriate national or international standards regarding protection against hazards generated from electricity, gas emission and electrolyte from lead-acid and NiCd batteries.						

If natural ventilation is impractical or insufficient, mechanical ventilation shall be provided.

Where mechanical ventilation is employed, the charging system(s) shall be interlocked so as to switch off if the ventilation fails. A warning device shall be provided and operate if failure occurs.

Switches and fuses or other equipment which may generate sparks shall not be placed in battery compartments or containers.

Cable entries to battery compartments shall be gastight.

4.10 Battery chargers

4.10.1 Protection against overcharging and reversal of charging current

Chargers shall incorporate protection against overcharging and overvoltage and shall have a charge indicator. Protection against reversal of the charging current shall be provided.

4.10.2 Wind generator and photovoltaic devices

Charge regulators used with a wind generator or photovoltaic cells shall be specially designed for use in such systems. They may be used to charge battery installations with an output voltage limit set to the gassing voltage appropriate for the battery.

4.11 Internal communication circuits

Where a communication circuit takes its supply direct from the power or lighting circuits and exceeds the safety voltage, all equipment shall be in accordance with the requirements for final circuits.

4.12 Electrical apparatus for explosive gas atmospheres

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 connections(s) between components of a petrol system, and in compartments or lockers containing LPG cylinders and/or pressure regulators, shall conform to the IEC 60079 series and/or ISO 8846, ISO 10239 and ISO 9094-1 and ISO 9094-2.

NOTE Open compartments having 0,34 m² of open area per cubic metre of compartment volume exposed to the open atmosphere outside the vessel constitute an exception to this requirement.

4.13 Electrical fittings and cables attached to structures of another metal

If electrical fittings are attached to structures of another metal, for instance aluminium, suitable precautions shall be taken to prevent galvanic corrosion.

4.14 Navigation lights supply

All sea-going vessels of every type are required to comply with the International Regulations for the Preventing of Collisions at Sea 1972, as amended. The construction and installation of navigation lights shall be to the satisfaction of the appropriate authority.

Navigation lights, if required, shall each be separately connected to a dedicated distribution board, placed in an accessible position on the vessel. Provision shall be made at this position for the navigation lights to be transferred to an alternative supply source.

4.15 Luminaires

Luminaires shall comply with the relevant requirements of IEC 60092-306.

Luminaires likely to be exposed to a risk of mechanical damage shall either be protected against such damage or be of specially robust construction. The construction and installation of luminaires should be appropriate to their location and environment.

4.16 Electrical heating and cooking appliances

Electrical heating and cooking appliances shall comply with the relevant requirements of IEC 60092-307.

4.17 Magnetic compasses

Conductors and equipment shall be placed at such a distance from the compass, or shall be so screened, that the interfering external magnetic field is negligible, causing a compass deviation of no more than 30' when the circuits are switched on or off under maximum load.

5 Distribution systems

5.1 DC distribution systems

The d.c. distribution systems shall be

- a) either fully insulated two wire d.c. system;
- b) or a two-wire d.c. system with negative earth.

5.2 Standard a.c. distribution systems

5.2.1 Types of a.c. distribution system

The systems shall be either, or a combination of

- a) single-phase systems or final circuits
 - 1) single-phase two-wire insulated;
 - 2) single-phase two-wire with neutral earthed;
 - 3) single-phase two-wire with mid-point earthed for lighting and socket-outlets;
 - 4) single-phase three-wire with mid-point earthed, but without hull return;
- b) three-phase systems
 - 1) three-phase three-wire insulated three-phase (IT);

- 2) four-wire with neutral earthed (TN-C type) but without hull return;
- 3) five-wire with neutral earthed (TN-S) but without hull return.

5.2.2 Earthing the neutral conductor in type TN a.c. systems

The neutral conductor of an a.c. system shall be grounded (earthed) only at the source of power, for example, at the onboard generator. When a vessel is connected to shore-power, the neutral shall be grounded only at the shore-power source through the shore-power cable unless an isolating transformer is fitted to the vessel when the neutral shall be grounded at the secondary of the isolating transformer.

Earthed neutral systems shall be designed so that the potential earth fault current will not exceed the design capacity of any part of the system and such current is of sufficient magnitude to operate any protection. Where the neutral point is connected directly to earth, the earth loop impedance should 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.

5.2.3 Earthing of non-current-carrying parts in a.c. systems

The purpose of earthing and bonding of non-current-carrying parts of an electrical system is to reduce the danger of shock to personnel and to minimize damage to equipment from the effects of earth currents. These can occur from failures of insulation of live conductors, induced voltages and currents.

In steel-hulled vessels, the presence of a large comparative cross-section area of metal for earth return paths enables a simple method of earthing and bonding (TT and IT systems) in which non-current-carrying parts can be bonded direct to the hull of the vessel. A vessel with a non-metallic hull requires to be provided with a protective conductor (which may be separate from the neutral conductor (TN-S) or not separate (TN-C)).

Exposed metal parts of electrical machines or equipment shall be earthed unless the machine or equipment is:

- supplied at safety voltage;
- supplied at a voltage not exceeding 230 V nominal by an isolating transformer supplying only one consuming device;
- constructed in accordance with the principle of double insulation (see 6.5).

5.2.4 Protective conductor in a.c. systems

The a.c. protective conductor(s) shall be provided with a final connection to the hull of a metallic hull vessel, or if the vessel has a non-metallic hull to the external main earthing plate (see Clause 10.1.2) of the vessel. On larger installations, a main earth conductor bar may be used to connect all protective conductors at one location before the final connection is made.

The protective conductor final connection shall be made at a location above any anticipated water accumulation.

5.3 Bonding conductors

In d.c. and a.c. systems the earth bonding should be such as to give substantially equal potential and sufficiently low earth fault loop impedance to ensure correct operation of protective devices. Extraneous conductive parts which are connected to hull of a steel vessel by permanent and reliable metal to metal joints of negligible impedance need not be bonded by separate earthing conductors.

Every earthing conductor shall be of copper or other corrosion-resistant material and shall be securely installed and protected where necessary against damage and where necessary against electrolytic corrosion.

The bonding conductor may be insulated – the colour of the insulation for d.c. and a.c. installations shall be green and yellow stripes. This colour combination shall not be used for current-carrying conductors.

5.4 Balance of loads in three-phase a.c. systems

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

5.5 Shore connection arrangements

5.5.1 General

Where a vessel requires connection of an a.c. supply from shore, a suitable shore supply inlet shall be installed on the vessel for the connection of the flexible cable(s) from the shore supply socket outlet. The vessel's a.c. neutral shall be arranged to be earthed only at the shore supply when the shore supply is switched to supply the vessel's a.c. system (i.e. the vessel's a.c. neutral shall be disconnected from the vessel's earth when shore power is connected unless the vessel is fitted with an isolating transformer (see 5.2.2)).

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

5.5.2 Vessel connections

Only one vessel shall be connected at any one time to a single shore supply socket outlet. Article A.1 provides details of the connection instructions advised for inclusion in the vessel owner's manual (ISO 10240) and details of the information to be included at the shore power supply location in accordance with IEC 60364-7-709.

The flexible shore power cable shall be provided with the following connecting arrangements:

- a) a plug conforming to IEC 60309-1 or IEC 60309-2 to connect to the shore supply socket outlet;
- b) a flexible cable, type 245 in IEC 60245-4 or equivalent, which is either permanently connected to the vessel or connected to a plug conforming to IEC 60309-2 to connect to a shrouded male type socket inlet on board the vessel.

NOTE See examples given in Clause A2.

5.5.3 Changeover switch for a vessel with its own a.c. power system

For vessels which are fitted with a.c. generation supplying on-board systems, an interlocked changeover switch shall prevent parallel connection between the shore power supply and the on-board generation. The changeover switch shall be of a type suitable for isolation and shall include all phases and neutral. The vessel's changeover switch shall be provided with an indicator in order to show when the shore supply is energized.

5.5.4 Information and connection instructions

Information and instructions shall be provided giving full information on the system of supply, the nominal voltage and frequency of the vessel's system and the procedure for carrying out the connection. Information on the phase sequence for three-phase a.c. systems shall also be given for three-phase connections.

The instructions provided on board the vessel shall include as a minimum that detailed in A.1.2.

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

6.1 Protection against direct contact

Live parts shall be protected against accidental contact by the use of enclosures in accordance with 4.7.2.

All exposed non-current-carrying conductive parts shall be connected to earth either via the protective conductor or by connection direct to the hull of a steel vessel.

6.2 Automatic disconnection of supply to final circuit or equipment

A protective device (fuse, circuit-breaker or RCD) shall automatically disconnect the supply to the circuit or equipment in the event of a fault between a live part and an exposed non-current-carrying conductive part.

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

6.3 Earthed neutral systems

In earthed neutral systems the source is connected direct to earth, and all exposed conductive parts of the installation shall be connected to the earthed point of the vessel's power system by protective conductor(s) TN-system.

In earthed neutral systems, the protective arrangements for final circuits particularly to locations in confined or exceptionally damp spaces where particular risk due to conductivity may exist shall be:

- a) an overcurrent protective device;
- b) a residual-current protective device with sensitivity of 30 mA maximum for final circuits to locations where there is an increased risk of personal contact with live conductive parts.

6.4 Non-neutral earthed system (IT-type system)

IT-type systems are permissible when continuity of service is requested; otherwise, a TN system is acceptable. In IT systems the vessel's phase conductor(s) is insulated from earth and the star point either isolated from earth or deliberately connected to earth through a sufficiently high impedance.

In IT-type systems, it is permissible for a single fault between a live part and an exposed conductive part to occur without automatic disconnection, provided that earth monitoring or permanent insulation controller is fitted. A second fault shall result in automatic disconnection. A prospective touch voltage exceeding 50 V a.c. shall not persist for a time sufficient to cause a risk of harmful physiological effect in a person.

NOTE Special arrangements may need to be made for essential services in IT type systems.

In IT-type systems, the protective arrangements particularly to locations in confined or exceptionally damp spaces where particular risk due to conductivity may exist shall be

- a) an overcurrent protective device;

- b) a residual-current protective device with sensitivity of 30 mA maximum for final circuits to locations where there is an increased risk of personal contact with live conductive parts.

6.5 Use of class II equipment

Protection by use of class II equipment given in IEC 60536 or by equivalent insulation is intended to prevent the appearance of dangerous voltages on accessible parts of electrical equipment due to a fault in the basic insulation.

7 Protection against over-current and fault-current

7.1 General

Every circuit shall be protected against overload and short circuit by a fuse or circuit-breaker.

Fuses and circuit-breakers used shall be selected from those manufactured in accordance with the appropriate IEC standard.

Final circuits connected to a distribution panel or switchboard shall be protected, unless otherwise specified, by a fuse or circuit-breaker. These circuits may be controlled by single-pole switches when they are supplied at a voltage not exceeding safety voltage or else by multi-pole switches, unless in dry spaces within the accommodation.

Each fuse or circuit-breaker at the source of a circuit shall be designed to protect the smallest conductor in the circuit being protected.

7.2 Characteristics of protective devices

Each protective device shall be selected in such a way 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 not 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 shall be in accordance with the prospective short-circuit or earth-fault current at the point at which the device is installed. If the short-circuit breaking or making capacity is less than the protective device, it shall be backed up by a fuse or circuit-breaker in accordance with IEC 60092-202, 6.1.3 and 6.2.

7.3 DC system

A fuse or circuit-breaker shall, as a minimum, be installed in the positive pole of each circuit being supplied by a battery within 200 mm of the battery terminals. If this is impractical, each conductor from the battery shall be contained within a protective covering, such as cable conduit, ducting pipes or 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 the battery to an engine-cranking motor, if sheathed or supported to protect against abrasion and contact with conductive surfaces;
- b) the main power-feed cable 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.

NOTE When conductors from batteries are not protected against short circuit and overload, they should be installed so as to be proof against short circuits and earth faults by using

- a) single-core cable without metal sheath, armour, braiding/screen;

- b) single-core insulated cable mounted on supports manufactured from insulating material. Penetrations should be made in insulated material;
- c) uninsulated conductors mounted on insulators and with insulated penetrations;
- d) single-core un-insulated cables in insulated conduits, with one cable in each conduit.

7.4 AC system

7.4.1 Protective devices

Protective devices shall be selected in accordance with IEC 60898-1. Circuits shall be designed to ensure coordination between protective devices in series.

Over-current and fault-current protective devices shall not interrupt protective conductors.

In three-phase circuits with substantially balanced loads, fault current protection can be limited to a single phase of the circuit being protected. When fuses are used to protect three-phase motor circuits, consideration shall be given to protection against single-phasing.

7.4.2 Final circuits

Final circuits supplied from a switchboard or distribution board, and control circuits for an engine, other than starting and ignition circuits, shall be protected against overload and short circuit by a protective device in each line pole. Over-current protection devices shall have a short-circuit rating equal to, or in excess of, the calculated short-circuit current at the point where the device is installed.

7.5 Generators

7.5.1 Small generators in d.c. systems

The positive conductors of output circuits of self-limiting alternators and battery chargers not exceeding 2 kW do not require fuses or circuit breakers.

7.5.2 Use of fuses

Fuses shall not be used in conjunction with a switch or contactor to provide overload and short-circuit protection for generators of more than 50 kW d.c. or 50 kVA a.c.

The trip of a contactor in connection with a fuse shall be short-time delayed, with a maximum delay of 500 ms.

7.5.3 Generator circuit-breaker

A generator of more than 50 kW d.c. or 50 kVA a.c. shall be provided with a circuit-breaker in its output fitted with each of the following:

- a) thermal overload protection (for example, 15 s);
- b) short-circuit protection (for example, 500 ms);
- c) time-delayed under-voltage release (for example, 500 ms).

Generators for parallel operation shall be provided with reverse power protection. The tripping of the generator circuit-breaker shall be time-delayed (for example, 5 s to 15 s).

7.6 Transformers

Each transformer shall be protected by an individual overload and short-circuit device on the primary side, rated at not more than 125 % of the rated primary current of the transformer. It

shall be verified in the design of the system that faults on the secondary side shall cause the protection to operate.

7.7 Motor protection

Motors shall have protection against overload and short circuit. Where necessary, the following protections may be added:

- a) locked rotor;
- b) loss or serious unbalance of phases;
- c) thermal image;
- d) under-voltage.

8 Diversity (demand) factor

8.1 Circuits other than final circuits

Circuits supplying two or more final circuits shall be rated in accordance with the total connection load subject, where justifiable, to the application of a diversity (demand) factor in accordance with 8.2 and 8.4.

Where spare circuits are provided on a section or distribution board, an allowance for future increase in load shall be added to the total connected load, before the application of any diversity factor. The allowance shall 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.

8.2 Application of diversity (demand) factors

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

8.3 Final circuits

The cables of final circuits shall be rated in accordance with their connected load.

8.4 Motor power circuits

The diversity factor shall be determined according to the circumstances. The normal full load shall be determined on the basis of name-plate ratings in accordance with the ambient air temperature requirements in 4.2.

9 Cables

9.1 Selection of cables

9.1.1 Cables for d.c. systems

Cables for d.c. systems shall comply with IEC 60092-350.

9.1.2 Cables for a.c. systems

Cables for a.c. systems shall have a minimum voltage rating as follows:

- a) 1 000 V for 120/230 V systems;
- b) 1 000 V for 440 V three-phase systems.

Cables shall conform to IEC 60092-350 and be installed in accordance with IEC 60092-401.