INTERNATIONAL STANDARD

IEC 60092-503

Second edition
2007-06

Electrical installations in ships –

Part 503:
Special features –
AC supply systems with voltages in the range of above 1 kV up to and including 15 kV

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 503: Special features – AC supply systems with voltages in the range of above 1 kV up to and including 15 kV

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60092-503 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and offshore units

This second edition cancels and replaces the first edition published in 1975. This edition constitutes a technical revision.

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

a) The scope is changed to an upper limit of the system voltage from 11 kV to 15 kV.
b) General requirements regarding warning notices, access to installations, clearances and creepage distances of uninsulated conductors and earthing have been introduced.
c) Technical review has generally been made to update the standard according to general requirements and referenced equipment standards.

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

FDIS	Report on voting
18/1053/FDIS	18/1059/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 parts of the IEC 60092 series, 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.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

IEC 60092 forms a series of International Standards for electrical installations in sea-going ships, incorporating good practice and coordinating, as far as possible, existing rules.

These standards form a code of practical interpretation and amplification of the requirements of the International Convention for the Safety of Life at Sea, a guide for future regulations which may be prepared, and a statement of practice for use by shipowners, shipbuilders and appropriate organizations.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 503: Special features – AC supply systems with voltages in the range of above 1 kV up to and including 15 kV

1 Scope

This part of IEC 60092 is applicable to a.c. supply systems with voltages from 1 kV up to and including 15 kV. The requirements contained in other parts of IEC 60092 apply where appropriate, subject to the exceptions stated in the following clauses.

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 60034 (all parts), *Rotating electrical machines*

IEC 60038:1983, *IEC standard voltages*

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-2, *Insulation co-ordination – Part 2: Application guide*

IEC 60076 (all parts), *Power transformers*

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

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

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

IEC 60092-353, *Electrical installations in ships – Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV*

IEC 60092-354, *Electrical installations in ships – Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV, (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60265-1, *High-voltage switches – Part 1: Switches for rated voltages above 1 kV and less than 52 kV*

IEC 60282-1:2005, *High-voltage fuses – Part 1: Current-limiting fuses*

IEC 60502 (all parts), *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60502-1, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 1: Cables for rated voltages of 1 kV (U_m = 1,2 kV) up to 3 kV (U_m = 3,6 kV)*

IEC 60502-2, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60694:1996, *Common specifications for high-voltage switchgear and controlgear standards*

IEC 62271(all parts), *High-voltage switchgear and controlgear*

IEC 62271-200:2003, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 AC voltages

For alternating voltages, the voltages stated below are r.m.s. values.

3.1.1
nominal system voltage
voltage by which a system is designated

[IEC 60038, Clause 1]

3.1.2
highest and lowest voltages of a system (excluding transient or abnormal conditions)

3.1.2.1
highest voltage of a system
highest value of voltage which occurs under normal operating conditions at any time and at any point on the system

NOTE It excludes voltage transients, such as those due to system switching and temporary voltage variations.

[IEC 60038, 2.1, modified]

3.1.2.2
lowest voltage of a system
lowest value of voltage which occurs under normal operating conditions at any time and at any point on the system

NOTE It excludes voltage transients, such as those due to system switching and temporary voltage variations.

[IEC 60038, 2.2, modified]

3.1.2.3
highest voltage for equipment

maximum value of the "highest system voltage" (see 3.1.2.1) for which the equipment may be used

NOTE Attention is drawn to the fact that in some equipment standards the term "voltage range" has a different meaning.

[IEC 60038, Clause 9, modified]

3.2 Earthed neutral systems

3.2.1
high-resistance earthed neutral
system where the neutral is earthed through a resistance with numerical value equal to, or somewhat less than, one-third of the capacitive reactance between phase and earth

3.2.2
low-resistance earthed neutral
system where the neutral is earthed through a resistance which limits the earth fault current to a minimum value of 20 % and a maximum value of 100 % of the rated current of the largest generator

3.3 Insulation

3.3.1
insulation coordination
selection of the dielectric strength of equipment in relation to the voltages which can appear on the system for which the equipment is intended and taking into account the service environment and the characteristics of the available protective devices

[IEC 60071-1, 3.1]

3.3.2
rated insulation level
set of rated withstand voltages which characterize the dielectric strength of the insulation

[IEC 60071-1, 3.35]

4 General requirements

4.1 Voltage and frequency

Voltage and frequency shall be chosen in accordance with IEC 60038. The maximum nominal system voltage is 15 kV. The preferred values for ship supply systems are stated in Table 1.

Table 1 – AC three-phase systems having a nominal voltage above 1 kV and up to and including 15 kV

Nominal system voltage[a] kV	Nominal frequency Hz	Highest voltage for equipment kV
3	50 or 60	3,6
3,3		3,6
6		7,2
6,6		7,2
10		12
11		12
15		17,5

[a] The values are voltages between phases.

4.2 Warning notices

Warning notices shall be fixed in a visible position:

- both inside high-voltage rooms and at the entrance; and
- on high-voltage equipment.

4.3 Access

Live parts of the installation shall have an earthed screen, earthed enclosure or approved insulation by the appropriate authority.

Live parts, which are to be operated or examined, shall be located and protected in such a way that they can be operated or examined easily and without danger.

4.4 Insulation level

The conditions on board ships may require certain equipment having an insulation level higher than that of the nominal voltage of the system, see IEC 60071-1 and IEC 60071-2. This shall be agreed between the manufacturer and the purchaser.

4.5 Clearances and creepage distances

4.5.1 Clearance distance

Uninsulated conductors which are not earthed shall be installed with a clearance from one another and from other conductive objects and from walls, ceilings or their own protective covers of at least 5 cm + 0,5 cm for each 1 kV of operating voltage, unless voltage tests carried out according to other similar standards confirm that the insulation is adequate with less clearance. Other minimum clearances may be considered in each case.

Minimum clearances for equipment are given in Table 2.

Table 2 – Minimum clearance for equipment

Nominal voltage V	**Minimum clearance distance** mm	
	Main switchboard	**Other equipment and generators**
< 1 100	14[a]	14
< 3 300	32	26
< 6 600	60	50
< 11 000	100	80
≤ 15 000	X[b]	X[b]

[a] A distance of 25 mm is required for busbars and other bare conductors in main switchboards.

[b] Values under consideration.

4.5.2 Creepage distance

All equipment shall have satisfactory creepage distances.

Minimum creepage distances for main switchboards and generators are given in Table 3 and minimum creepage distances for other equipment are given in Table 4.

Table 3 – Minimum creepage distances for main switchboards and generators

Nominal voltage	Minimum creepage distance for proof tracking index mm			
V	**300 V**	**375 V**	**500 V**	**> 600 V**
< 1 100	26 [a]	24 [a]	22 [a]	20 [a]
< 3 300	63	59	53	48
< 6 600	113	108	99	90
< 11 000	183	175	162	150
≤ 15 000	X [b]	X [b]	X [b]	X [b]

[a] A distance of 35 mm is required for busbars and other bare conductors in main switchboards.

[b] Values under consideration.

Table 4 – Minimum creepage distances for other equipment

Nominal voltage	Minimum creepage distance for proof tracking index mm			
V	**300 V**	**375 V**	**500 V**	**> 600 V**
< 1 100	18	17	15	14
< 3 300	42	41	38	26
< 6 600	83	80	75	70
< 11 000	146	140	130	120
≤ 15 000	X [a]	X [a]	X [a]	X [a]

[a] Values under consideration.

4.6 Earthing

Earthing conductors shall generally be of copper and shall have a cross-section area of at least 35 mm^2. The current density shall not exceed 150 A/mm^2 for copper earthing conductors at the maximum earth fault which may occur.

All busbars and all switchgear for incoming and outgoing circuits which may be energized from outside the switchgear, shall be equipped with fixed earthing switches. Unless reliable mechanical interlocks are provided, fixed earthing switches shall have adequate making capacity for operation on system voltage.

In other locations earthing and short-circuiting shall be carried out by means of fixed earthing switches, portable earthing equipment or other suitable earthing equipment which is approved by the appropriate authority

The secondary winding of current and voltage transformers shall be earthed. The earthing conductor shall be of copper and have a minimum cross-section area of 4 mm^2. The earthing conductor may be connected direct to the earthed enclosure of the transformer or to an earthed support.

Arrangements making it possible to establish local safety earthing shall be provided where cables are implemented.

4.7 Distribution systems

The following distribution systems shall be used:

– three-phase three-wire with high-impedance earthed neutral;
– three-phase three-wire with low-impedance earthed neutral;
– three-phase three-wire with directly earthed neutral; or
– three-phase three-wire with insulated neutral;

NOTE 1 For tankers, see IEC 60092-502[1].

NOTE 2 For insulated neutral systems, transient overvoltages may occur in the event of intermittent earth faults, and special consideration should be given to the dielectric strength of insulation.

NOTE 3 If the neutral point of the system is connected to earth with an impedance (resistance or reactance), the induced overvoltage will be higher than when it is connected with direct neutral earthing on the occurrence of an earth fault.

Where neutrals are earthed direct, it shall be ascertained that the equipment can withstand the earth-fault current which may result from a single-phase earth fault. If means are provided for limiting earth-fault currents, this shall not influence selectivity.

Means of disconnection shall be fitted in the neutral earthing connection. Locking arrangements shall be considered.

4.7.1 Divided system

Where an earthed system is divided into two or more sections, means for neutral earthing shall be provided for each section.

4.7.2 Auxiliary circuits

When auxiliary power is needed for the operation of switches, an independent auxiliary power system shall be provided for each of the switchboard sections. The auxiliary power systems shall have sufficient capacity for at least two operations of each circuit-breaker on the system.

NOTE This requirement applies to switches being simultaneously disconnected and without any abnormal voltage drop in the auxiliary power circuit or any abnormal drop of pressure in the hydraulic system used for switch operation.

When auxiliary power is used for the cooling system of a generator, either it shall be interlocked so that the generator is disconnected if the auxiliary power fails, or the generator shall have winding temperature detectors which actuate an alarm at the maximum rated winding temperature and disconnect the generator at 10 % overtemperature.

4.7.3 Busbars of main switchboards

The busbars of the main switchboard shall be divided into at least two independent sections by the use of at least a circuit breaker rated for load switching. Connections from generators to important services shall be divided between the sections so that safe operation of the ship is ensured even with any one busbar section out of service.

Means shall be provided for the disconnection of all circuit-breakers and fused circuit-breakers from the busbars.

NOTE Such means may be a disconnector having a visible isolating distance or gap, or a reliable position-indicating device for each movable contact system, or similar visible means, for example, a withdrawable mulitipole circuit-breaker in its isolating position.

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[1] IEC 60092-502:1999, Electrical installations in ships – Part 502: Tankers – Special features.

4.7.4 Generator circuits

Each generator output circuit shall be connected through a circuit-breaker. In addition to the general requirements, a protection device shall be provided to include protection against short circuit or earth fault in the generator or in the cable connection from the generator to the switchboard by disconnection of the generator circuit-breaker and de-excitation of the generator.

4.7.5 Outgoing circuits

Feeder circuits shall normally be connected through a circuit-breaker which provides overload and short-circuit protection.

A fused circuit-breaker may be accepted provided that fuses can be replaced without any hazard to personnel. Fuses shall not be used for overload protection.

Switchgear for downstream circuits may be used as motor-starters only if the switchgear is designed for the starting current and the stipulated number of switching operations.

NOTE 1 Certain types of fuses have an insufficient breaking capacity at currents between rated load and short circuit.

NOTE 2 When using fused circuit-breakers, it is assumed that the overcurrent protection device of the circuit-breaker operates within the current range.

4.7.6 Power-transformer circuits

Supply circuits to the primary side of transformers shall comply with the requirements of outgoing circuits.

If the power transformers are arranged for parallel operation, the secondary side circuits shall be provided with switchgear complying with the requirements of outgoing circuits. The switchgear on the secondary side shall be interlocked with the switchgear on the primary side.

4.7.7 Shore-connection circuits and circuits to other units

Shore-connection circuits shall be installed if agreed between the manufacturer and the purchaser.

Circuits to other units shall only be installed if necessary.

4.7.8 Control and instrumentation circuits

Except for short connections to instrument transformers, relays, auxiliary switches, etc., control and instrumentation circuits shall be installed separated from main circuits by means of partitions of insulating and flame-retardant material.

Alternative cable connections may be accepted.

Fuses in control and instrumentation circuits requiring attention while the equipment is in service shall be accessible without any hazard to personnel.

NOTE The requirement concerning partitions may be effected, for example, by using cable conduits.

4.8 Generator and transformer neutrals

4.8.1 Generator neutrals interconnected

If generators are intended to run with neutrals interconnected, manufacturers shall be informed so that the machines can be suitably designed to avoid excessive circulating currents. This is particularly important if they are of differing size and make.

4.8.2 Disconnection

A disconnect device shall be fitted in the neutral earthing connection of each a.c. generator so that the generator may be disconnected for maintenance.

4.9 Electrical protection

4.9.1 General

In addition to the general requirements of IEC 60092-202, the following requirements apply:

4.9.2 Generator protection

The faults on the generator side of a circuit-breaker are regarded as phase-to-earth or phase-to-phase. Consideration shall also be given to protection against interwinding faults.

4.9.3 Motor protection

When a single consumer, such as a bow thruster, is supplied direct at a higher voltage via a step-up transformer, the protection on the low-voltage side of the transformer shall be considered adequate.

4.9.4 Power-transformer protection

For short-circuit protection at the primary side, circuit-breakers are preferred. If fuses are used and if the total connected load of all outgoing circuits on the secondary side exceeds the rated capacity of the transformer, consideration shall be given to an overload protection (such as a circuit breaker set within the rated capacity of the transformer) or to an overload alarm being provided.

When transformers are connected in parallel, tripping of the protective device at the primary side shall automatically trip the switch connected at the secondary side.

The protection system shall include alarm for overcurrent or overtemperature if a load diversity factor has been used when deciding the current rating of the transformer.

4.9.5 Voltage-transformer protection

Voltage-transformers for control and instrumentation shall be protected against short circuit by fuses on the primary and on the secondary sides. Fuses may be omitted in circuits to voltage detectors in generator voltage regulators.

4.9.6 Overvoltage protection

Overvoltage protection shall be arranged for lower voltage systems supplied through transformers from high-voltage systems. The protection device, for example, a neutral voltage limiter or direct earthing of the lower voltage system shall be fitted at the secondary winding of the transformer. Alternative protection, such as a metallic screen connected to earth between primary and secondary windings of a transformer shall be provided.

4.9.7 Earth-fault monitoring

On systems designed with an insulated neutral or with high-resistance earthed neutral, where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment shall be designed for the phase-to-phase voltage.

On systems designed with low-resistance or directly earthed neutral provision shall be made to automatically disconnect the faulty circuits.

In addition, a fixed monitoring device giving a visual and audible alarm in the event of an insulation fault or earth fault in the installation shall be provided.

5 Equipment

All equipment shall be according to relevant IEC standards with the deviations and supplementary requirements for marine applications.

Enclosures shall comply at least with the requirements in IEC 60092-201, Clause 26, unless the following higher degree of protection is required.

The highest voltage for the equipment shall be specified with respect to

a) the insulation;
b) other characteristics which may be referred to this highest voltage in the relevant equipment recommendations.

NOTE It is understood that, particularly for certain nominal system voltages, normal operation of equipment cannot be ensured up to this highest voltage for equipment, having regard to voltage-sensitive characteristics such as losses of capacitors, magnetizing current of transformers, etc. In such cases, the relevant recommendations should specify the limit to which the normal operation of this equipment can be ensured.

5.1 AC generators and motors

The a.c. generators and motors shall generally be in accordance with the relevant parts of IEC 60034.

5.1.1 Enclosures

Rotating machines and neutral resistors installed in spaces accessible to unauthorised personnel shall have a degree of protection against contact with live or moving parts of at least IP4X.

NOTE 1 In rooms which are accessible for authorised persons only, a degree of protection IP23 can be accepted.

NOTE 2 Machinery spaces will generally be considered as being accessible only to qualified persons. The same applies to the compartments which normally are kept locked under the responsibility of the ship's officers.

Connection boxes shall have a degree of protection of at least IP44.

5.1.2 Performance

5.1.2.1 Temperature monitoring

The windings of all rotating machines shall be provided with temperature detectors for monitoring and alarm. Overvoltage protection shall be considered for temperature detector circuits.

5.1.2.2 Stator winding circuit arrangement

Generator stator windings shall have all phase ends brought out for connection of stator protection.

5.1.2.3 Generator performance at transformer switching

The performance of generators with excitation influenced by inrush current for the switching on of large transformers should be agreed upon by the manufacturer and the purchaser (see also 5.2.4).

5.1.3 De-excitation

The excitation system shall be so designed that a faulty generator will be de-excited automatically.

5.1.4 Mechanical characteristics

5.1.4.1 Accumulation of moisture and condensation

Effective means shall be provided to prevent accumulation of moisture and condensation within the machines especially when they are idle for appreciable periods.

NOTE Space heaters may be used for this purpose.

5.1.4.2 Water coolers

Means for easy inspection of water cooler leakage shall be provided as well as indication of leakage by alarm.

NOTE Consideration should be given to the use of double tubes in water coolers.

5.1.4.3 Terminals

Terminals of rated voltages above 1 kV shall not be combined with terminals of voltages below 1 kV in the same box, unless measures have been taken to ensure that access to the latter terminals can be obtained without danger.

Terminals of motors shall be arranged in terminal boxes.

Wherever practicable, all conductors shall be effectively covered with suitable insulating material. If the conductors are not insulated, phases shall be separated from earth and from each other by substantial barriers of suitable insulating material.

Adequate space shall be provided to ensure efficient cable terminations.

5.2 Transformers

The transformers shall generally be in accordance with the relevant parts of IEC 60076.

This clause applies to power transformers, reactors, and neutral earthing transformers.

NOTE Attention is drawn to the fact that difficulties may be experienced if transformers are connected star/star. These difficulties will be associated with earth-fault conditions and third harmonics.

5.2.1 Enclosures and installations

When installed in spaces accessible only to authorised personnel, transformers and reactors, together with their enclosures, shall have at least a degree of protection in accordance with IP23.

For transformers and reactors installed elsewhere, the degree of protection shall be at least in accordance with IP54.

Alternatively, where transformers are not contained in an enclosure but a transformer room forms the enclosure of the transformer, the door of the room shall be interlocked with the supply switchgear.

5.2.2 Accumulation of moisture and condensation

Effective means shall be provided to prevent accumulation of moisture and condensation within the reactors and transformers especially when they are idle for appreciable periods.

NOTE Space heaters may be used for this purpose.

5.2.3 Transient voltage conditions

When the largest consumer on the low voltage side of a distribution transformer is switched on, the transient voltage drop shall not be more than 15 % (voltage drop on primary side included).

5.2.4 Current inrush

Special attention shall be given to the current inrush and, as a consequence, voltage dip at the primary side when transformers are switched on. This is particularly the case when a second transformer is being switched in parallel or when the relationship between the ratings of generator and transformers is not compatible. Means for reduction of current inrush shall be considered if necessary.

NOTE In the absence of transformer characteristics, the asymmetrical peak value of the current inrush should be considered to reach a maximum value up to 15 I_n after the first half-cycle.

5.3 Switchgear and controlgear assemblies (switchboards)

5.3.1 Design and construction

Switchboards shall be of metal-enclosed construction in accordance with IEC 62271-200 with the deviations and supplementary requirements for marine applications.

NOTE The deviations and supplementary requirements are under consideration. Until this is developed the requirements in the following subclauses apply.

Switchgear and controlgear assemblies shall have a degree of protection of at least IP32.

Internal partitions of materials other than metal can be accepted by the appropriate authority after consideration of each case.

On outgoing circuits, if reverse energizing from the load side is not possible, enclosure between the cable terminals and the switchgear can be omitted.

Switchgear or controlgear is considered to be metal-enclosed when it consists of an outer metal enclosure with components arranged in separate metal-enclosed compartments. The metal enclosures shall be earthed.

Doors of switchboards shall be equipped with locking devices. Alternatively, the switchboard can be located in a special room or fenced-in area with lockable entrance doors provided sufficient means are included to allow the safe operation and maintenance of the equipment therein.

Except for short connections to instrument transformers, relays, auxiliary switches, etc., control and instrumentation circuits shall be installed separated from main circuits by means of partitions of insulating and flame-retardant material. Alternative cable connections can be accepted.

NOTE The requirement concerning partitions can be effected, for example, by using cable conduits.

Control and instrumentation circuits shall be installed separately from main circuits by means of metal or insulating and flame retardant material partitions, except for short connections to instrument transformers, relays, auxiliary switches etc. Alternative cable-connections can be accepted.

5.3.2 Passageways

In front of each switchboard there shall be a passageway with a free width of at least 1 m. It is important for safe working, that if access is necessary from the rear of the switchboard, the passageway at the rear of the switchboard shall also be at least 1 m.

Switchboards doors, when in the open position, or withdrawable switchgear in their isolating position, shall not obstruct the passage ways.

Access from both the front and rear of the switchboard shall be provided if necessary.

5.4 Switchgear and controlgear and fuses

High-voltage switchgear and controlgear shall generally be in accordance with IEC 60265-1, IEC 60694, and the relevant parts of IEC 62271; fuses with IEC 60282-1.

Switchgear and controlgear shall be able to withstand all stresses due to short-circuiting and vibrations.

5.5 Cables

5.5.1 General

High-voltage cables shall generally be in accordance with relevant parts of IEC 60502 with special requirements for high-voltage cables on ships as given in IEC 60092-350, IEC 60092-353 and IEC 60092-354.

Flexible cables for portable equipment can only be used after special consideration in each case.

The rated voltages U_o/U (U_m) of cables in respect of the nominal voltage shall be in accordance with Table 1 of IEC 60502-1 and Table 1 of IEC 60502-2.

5.5.2 Installation

Cables for high voltage shall be installed separately from cables for low-voltage, for example, not grouped together or installed in the same conduit.

Installation of high-voltage cables in accommodation areas shall be avoided. Where high-voltage cables have to be routed through accommodation areas the cables shall be installed in enclosed cable transit systems.

Cables for high-voltage shall be specially marked.

5.5.3 Conductors and terminations

For terminations and joints not protected by earthed metal screens, the clearance distances shall be as laid down in Table 2.

If terminations are made in accordance with installation instructions from the manufacturer, these instructions should be considered to be sufficient documentation if relevant test reports are available.

Cable terminations shall not be made in the same enclosure as equipment at lower voltages.

5.5.4 Current rating

The requirements for cables with temperature class 85 °C given in IEC 60092-201, Table 6, shall be used with a derating factor of 10 %.

5.5.5 Testing

Cables with terminations and joints shall be subject to a voltage test after installation according to relevant parts of IEC 60502. This means a d.c. voltage test at least $4 \times U_0$ for 15 min. U_0 is the rated phase-to-earth voltage of the cable.

Alternatively, an a.c. voltage test may be accepted upon agreement with the cable manufacturer.

5.5.6 Socket-outlets

Socket-outlets may be used only with the special approval of the appropriate authority.

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