

INTERNATIONAL STANDARD

IEC
60092-352

Third edition
2005-09

Electrical installations in ships –
Part 352:
Choice and installation of electrical cables

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 352: Choice and installation of electrical cables

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 60092-352 has been prepared by subcommittee 18A: Cables and cable installations, of IEC technical committee TC 18: Electrical installations of ships and of mobile and fixed offshore units.

This third edition cancels and replaces the second edition published in 1997, of which it constitutes a technical revision. Main changes with respect to the second edition relate to:

- sizes of earth continuity conductors and equipment earthing connections;
- bending radii for cables rated at 3,6/6,0 (7,2) kV and above;
- current carrying capacities in amperes at core temperatures of 70 °C and 90 °C;
- tabulated current carrying capacities – defined installations.

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

FDIS	Report on voting
18A/277/FDIS	18A/280/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.

IEC 60092 consists of the following parts under the general title *Electrical installations in ships*:

- Part 101: Definitions and general requirements
- Part 201: System design – General
- Part 202: System design – Protection
- Part 203: System design – Acoustic and optical signals
- Part 204: System design – Electric and electrohydraulic steering gear
- Part 301: Equipment – Generators and motors
- Part 302: Low-voltage switchgear and controlgear assemblies
- Part 303: Equipment – Transformers for power and lighting
- Part 304: Equipment – Semiconductor convertors
- Part 305: Equipment – Accumulator (storage) batteries
- Part 306: Equipment – Luminaires and accessories
- Part 307: Equipment – Heating and cooking appliances
- Part 350: Shipboard power cables – General construction and test requirements
- Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables
- Part 352: Choice and installation of electric cables
- Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV
- 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)
- Part 359: Sheathing materials for shipboard power and telecommunication cables
- Part 373: Shipboard telecommunication cables and radio-frequency cables – Shipboard flexible coaxial cables
- Part 374: Shipboard telecommunication cables and radio-frequency cables – Telephone cables for non-essential communication services
- Part 375: Shipboard telecommunication cables and radio-frequency cables – General instrumentation, control and communication cables
- Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)
- Part 401: Installation and test of completed installation
- Part 501: Special features – Electric propulsion plant
- Part 502: Tankers – Special features
- Part 503: Special features – A.C. supply systems with voltages in the range above 1 kV up to and including 11 kV
- Part 504: Special features – Control and instrumentation

Part 506: Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk

Part 507: Pleasure craft

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.

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INTRODUCTION

IEC 60092 forms a series of International Standards concerning electrical installations in sea-going ships and fixed or mobile offshore units, incorporating good practice and co-ordinating as far as possible existing rules.

These standards form:

- a code of practical interpretation and amplification of the requirements of the International Convention on Safety of Life at Sea;
- a guide for future regulations which may be prepared and
- a statement of practice for use by owners and builders of ships and fixed or mobile and offshore units and other appropriate organisations.

This revision of IEC 60092-352 has been prepared by Maintenance Team 1 of IEC SC 18A, to update and include developments identified in other parts of the 60092 series of standards applicable to electric cables for electrical installations in ships, viz:

- the increase in maximum rated conductor temperature during normal operation for EPR, XLPE type insulations – see IEC 60092-351 – and the effect on current carrying capacities;
- the publication of IEC 60092-376 covering cables for control and instrumentation 150/250V(300V);
- changes in test methods to demonstrate the capability of cables to continue to operate in fire conditions and to limit the spread of flame;
- the inclusion of a method for the determination of current carrying capacities based upon those that have been accepted and established in other applications of cable use. This method has been derived from a technical basis and allows a greater choice of use in different installation methods as opposed to that currently specified, which was established from experimental data on a limited number of cables and installation information. The existing ratings are included as informative annexes A and B, and their use is valid under certain conditions, e.g. refurbishment of ships;
- the inclusion of a method for the determination of the cross-sectional areas of earthing conductors based on the current carrying capacities of the fuse or circuit protection device installed to protect the circuit.

NOTE Guidance for the use and installation of cables for offshore applications is being prepared jointly by SC18A, MT 2 and TC 18, MT 18, and will be issued by TC 18, MT 18.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 352: Choice and installation of electrical cables

1 Scope

This standard provides the basic requirements for the choice and installation of cables intended for fixed electrical systems on board ships at voltages (U) up to and including 15 kV.

The reference to fixed systems includes those that are subjected to vibration (due to the movement of the ship) or movement (due to motion of the ship) and not to those that are intended for frequent flexing. Cables suitable for frequent or continual flexing use are detailed in other IEC specifications e.g. IEC 60227 and IEC 60245, and their uses on board ship is restricted to those situations which do not directly involve exposure to a marine environment e.g. portable tools or domestic appliances.

The following types and applications of cables are not included:

- optical fibre cables;
- sub-sea and umbilical cables;
- data, telecommunication and radio frequency cables;
- the choice and installation of cables for use on offshore units.

2 Normative references

[IEC 60092-352:2005](https://standards.iteh.ai/catalog/standards/sist/af2c694b-84ca-47e1-b1ae-0d184f550b22/iec-60092-352-2005)

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

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

IEC 60092-203, *Electrical installations in ships – Part 203: System design – Acoustic and optical signals*

IEC 60092-350:2001, *Electrical installations in ships – Part 350: Shipboard power cables – General construction and test requirements*

IEC 60092-351, *Electrical installations in ships – Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables*

IEC 60092-353:1995, *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*
Amendment 1 (2001)

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 60092-359, *Electrical installations in ships – Part 359: Sheathing materials for shipboard power and telecommunication cables*

IEC 60092-376, *Electrical installations in ships – Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)*

IEC 60228:2004, *Conductors of insulated cables*

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

IEC 60331-21:1999, *Tests for electric cables under fire conditions – Circuit integrity – Part 21: Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV*

IEC 60331-31:2002, *Tests for electric cables under fire conditions – Circuit integrity – Part 31: Procedures and requirements for fire with shock – Cables of rated voltage up to and including 0,6/1,0 kV*

IEC 60332-1-2:2004, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-3-22:2000, *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 60533:1999, *Electrical and electronic installations in ships – Electromagnetic compatibility.*

IEC 60684-2:2003, *Flexible insulating sleeving – Part 2: Methods of test*
Amendment 1 (2003)

IEC 60702-1:2002, *Mineral insulated cables and their terminations with a rated voltage not exceeding 750V* <https://standards.iteh.ai/catalog/standards/sist/af2c694b-84ca-47e1-b1ae-0d184f550b22/iec-60092-352-2005>

IEC 60702-2:2002, *Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V – Terminations*

IEC 60754-1:1994, *Test on gases evolved during combustion of materials from cables – Determination of the amount of halogen acid gas.*

IEC 60754-2:1991 *Test on gases evolved during combustion of electric cables – Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity*
Amendment 1 (1997)

IEC 61034-2:2005 *Measurement of smoke density of cables burning under defined conditions – Test procedure and requirements.*

3 Types, construction, installation and operating conditions of cables

3.1 Types of cables

Cables constructed in accordance with IEC 60092-350, IEC 60092-353, IEC 60092-354, and IEC 60092-376 are recommended for use on board ships. Cables (and their terminations) for use in special applications which are constructed in accordance with IEC 60702-1 and IEC 60702-2 are also acceptable provided that due consideration has been given to their intended application and use in a marine environment.

3.2 Voltage rating

3.2.1 Power cables

The maximum rated voltage (U) considered in this standard for power cables is 15 kV.

In the voltage designation of cables $U_0 / U / (U_m)$:

U_0 is the rated power voltage between conductor and earth or metallic screen for which the cable is designed;

U is the rated power frequency voltage between conductors for which the cable is designed;

U_m is the maximum value of the highest system voltage which may be sustained under normal operating conditions at anytime and at any point in the system. It excludes transient voltage conditions and rapid disconnection of loads.

U_m is chosen to be equal to or greater than the highest voltage of the three-phase system. Where cables are permitted for use on circuits where the nominal system voltage exceeds the rated voltage of the cables, the nominal system voltage shall not exceed the maximum system voltage (U_m) of the cable.

Careful consideration shall be given to cables subjected to voltage surges associated with highly inductive circuits to ensure that they are of a suitable voltage rating.

The choice of standard cables of appropriate voltage designations for particular systems depends upon the system voltage and the system earthing arrangements

The rated voltage of any cable shall not be lower than the nominal voltage of the circuit for which it is used. To facilitate the choice of the cable the values of U recommended for cables to be used in three phase systems are listed in Table 1 in which systems are divided into the following three categories:

- **Category A**

This category comprises those systems in which any phase conductor that comes in contact with earth or an earth conductor is automatically disconnected from the system.

- **Category B**

This category comprises those systems that under fault conditions are operated for a short time, not exceeding 8 h on any single occasion, with one phase earthed. For example, for a 13,8 kV system of Category A or B, the cable should have a rated voltage not less than 8,7/15 kV.

NOTE In a system where an earth fault is not automatically and promptly eliminated, the increased stresses on the insulation of cables during the earth fault are likely to affect the life of the cables to a certain degree. If the system is expected to be operated fairly often with a sustained earth fault, it may be preferable to use cables suitable for Category C. In any case, for classification as Category B the expected total duration of earth faults in any year is not permitted to exceed 125 h.

- **Category C**

This category comprises all systems that do not fall into Categories A and B.

The nominal system voltages from 1,8/3 kV to 8,7/15 kV shown in Table 1 are generally in accordance with Series I in IEC 60038. For nominal system voltages intermediate between these standard voltages and also between 0,6/1 kV and 1,8/3 kV, the cables should be selected with a rated voltage not less than the next higher standard value. For example: – a first earth fault with one phase earthed causes a $\sqrt{3}$ higher voltage between the phases and earth during the fault. If the duration of this earth fault exceeds the times given for Category B, then according to Table 1, for a 6 kV system, the cable is to have a rated voltage not less than 6/10 kV.

A d.c. voltage to earth of up to a maximum of 1,5 times the a.c. U_0 voltage may be used. However, consideration should be given to the peak value when determining the voltage of d.c. systems derived from rectifiers, bearing in mind that smoothing does not modify the peak value when the semiconductors are operating on an open circuit.

Table 1 – Choice of cables for a.c. systems

System voltage		System category	Minimum rated voltage of cable U_0/U	
Nominal voltage U kV	Maximum sustained voltage, U_m kV		Unscreened kV	Single-core or screened kV
up to 0,25	0,3	A, B or C	0,15/0,25	-
1,0	1,2	A, B or C	0,6/1,0	0,6/1,0
3,0	3,6	A or B	1,8/3,0	1,8/3,0
3,0	3,6	C	—	3,6/6,0
6,0	7,2	A or B	—	3,6/6,0
6,0	7,2	C	—	6,0/10,0
10,0	12,0	A or B	—	6,0/10,0
10,0	12,0	C	—	8,7/15,0
15,0	17,5	A or B	—	8,7/15,0

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3.2.2 Control and instrumentation cables

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The maximum rated voltage (U) for control and instrumentation cables considered in this standard is 250 V.

[IEC 60092-352:2005](https://standards.iteh.ai/catalog/standards/sist/af2c694b-84ca-47e1-b1ae-64704539822/iec-60092-352-2005)

In some instances for conductor sizes $1,5 \text{ mm}^2$ and larger, or when circuits are to be supplied from a low impedance source, 0,6/1 kV rated cables are specified for use as control or instrumentation cables.

NOTE The use of $1,0 \text{ mm}^2$ is under consideration for 0,6/1 kV applications.

3.3 Cross-sectional areas of conductors and current carrying capacities

3.3.1 Cross-sectional areas of conductors

The cross-sectional area of each conductor shall be selected to be large enough to comply with the following conditions.

- The highest load to be carried by the cable shall be calculated from the load demands and diversity factors.
- The “corrected current rating” calculated by applying the appropriate correction factors to the “current rating for continuous services” shall not be lower than the highest current likely to be carried by the cable. The correction factors to be applied are those given in 3.3.4, 3.3.5 and 3.3.6.
- The voltage drop in the circuit shall not exceed the limits specified by the regulatory body for the circuits concerned – further guidance is given in 3.4.
- The cross-sectional area of the conductor shall be able to accommodate the mechanical and thermal effects of a short circuit current (see 3.8) and the effects upon voltage drop of motor starting currents (see Note 3 of 3.4).
- Class 5 conductors, where used, shall be subject to special consideration in respect of maximum current-carrying capacity. Class 5 conductors have, in most cases, a lower conductivity than the equivalent class 2 conductors of the same nominal cross-section.

- The nominal cross-sections of the earth conductor shall comply with Table 2. One of the alternative methods of determining the cross sectional area of each earthing conductor is that based upon the rating of the fuse or circuit protection device installed to protect the circuit. If this method is used, the nominal cross sectional area finally selected shall be the higher of any cross sectional areas determined by each of the methods.

Table 2 – Sizes of earth continuity conductors^a and equipment earthing connections

Arrangement of earth conductor		Cross-section Q of associated current carrying conductor (One phase or pole) mm ²	Minimum cross-section of earth conductor
1.	i) Insulated earth conductor in cable for fixed installation.	$Q \leq 16$	Q
	ii) Copper braid of cable for fixed installation according to 8.2 of IEC 60092-350. iii) Separate, insulated earth conductor for fixed installation in pipes in dry accommodation spaces, when carried in the same pipe as the supply cable. iv) Separate, insulated earth conductor when installed inside enclosures or behind covers or panels, including earth conductor for hinged doors as specified in IEC 60092-203.	$Q > 16$	50 % of the current-carrying conductor, but not less than 16 mm ²
2.	Uninsulated earth conductor in cable for fixed installation, armour or copper braid and in metal-to-metal contact with this.	$Q \leq 2,5$	1 mm ²
		$2,5 < Q \leq 6$	1,5 mm ²
		$Q > 6$	Not permitted
3.	Separately installed earth conductor for fixed installation other than specified in 1 iii) and 1 iv).	$Q < 2,5$	Same as current-carrying conductor subject to min. 1,5 mm ² for stranded earthing connection or 2,5 mm ² for unstranded earthing connection
		$2,5 < Q \leq 120$	50 % of current-carrying conductor, but not less than 4 mm ²
		$Q > 120$	70 mm ²
4.	Insulated earth conductor in flexible cable.	$Q \leq 16$	Same as current-carrying conductor
		$Q > 16$	50 % of current-carrying conductor, but minimum 16 mm ²
NOTE Refer also to 3.3.1 for a method based on the rating of fuses.			
^a The term protective conductor is accepted as an alternative term for the earth continuity conductor.			

3.3.2 Current carrying capacities

The procedure for cable selection employs rating factors to adjust the current carrying capacities for different ambient temperatures, for the mutual heating effects of grouping with other cables, methods of installation and short time duty. Guidance on the use of these factors is given below.

3.3.3 Current ratings for continuous service

Continuous service for a cable is to be considered, for the purpose of this standard, as a current-carrying service with constant load and having a duration longer than three times the thermal time constant of the cable, i.e., longer than the critical duration (see Figure 2).

The current to be carried by any conductor for sustained periods during normal operation shall be such that the appropriate conductor temperature limit is not exceeded.

The value shall either be:

- selected from one of the following annexes in accordance with the appropriate installation method:

Annex A: a method for determination of current carrying capacities based upon those that have been accepted and established in other applications of cable use. This method has been derived from a technical basis established from experimental data on a number of cables and installation information. It allows for greater choice of use in different installation configurations. For further reference see IEC 60364-5-52.

The basis of the determination is on the following formula:

$$I = A \times S^m - B \times S^n$$

where

I is the current carrying capacity (A);

S is the nominal cross-sectional area of conductor (mm²);

A and B are coefficients, m and n are exponents according to cable type and method of installation.

Values calculated using the above for various installations are given in Annex A together with guidance on selection.

Annex B: a method for the determination of current carrying capacities as given in the second edition (1997) of IEC 60092-352. The values were initially established in 1958 based on limited experimental data and have been both amended and their range extended in attempts to reflect the changes in construction of cables and their maximum conductor operating temperatures which have taken place. They are only valid for a limited number of installations under certain conditions. It is recommended that they are only used for refurbishment of ships or in conjunction with other guidance information.

The formula on which they are based is:

$$I = \alpha \cdot A^{0,625}$$

where

I is the current carrying capacity (A);

A is the nominal cross-sectional area of conductor (mm²);

α is a coefficient related to the maximum permissible service temperature of the conductor.

Values calculated using the above – given in Annex B – are only applicable when used in accordance with the basis as given;

- or be determined using one of the following methods:
 - as described by IEC 60287, or
 - by calculation using a recognised method provided that the method is stated, and where appropriate, account shall be taken of the characteristics of the load.

The selection of the method applicable to any particular installation is the responsibility of the appropriate approval authority or governing regulation.