भारतीय मानक

Indian Standard

IS 10242 (Part 3/Sec 12) : 2023
IEC 60092-352 : 2005

जहाजों में विद्युत संस्थापन — विशिष्टि

भाग 3 उपकरण

अनुभाग 12 शक्ति प्रणालियों के लिए केबलों का चयन और स्थापना

(पहला पुनरीक्षण)

Electrical Installation in Ships — Specification

Part 3 Equipment

Section 12 Choice and Installation of Electrical Cables

(First Revision)

ICS 47.020.60

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Electrical Installation Sectional Committee, ETD 20

NATIONAL FOREWORD

This Indian Standard (Part 3/Sec12) (First Revision) which is identical to IEC 60092-352 : 2005 'Electrical installations in ships — Part 352: Choice and installation of electrical cables' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electrical Installation Sectional Committee and approval of the Electrotechnical Division Council.

The text of IEC standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminologies and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60092-101 Electrical installations in ships — Part 101: Definitions and general requirements	IS 10242 (Part 1/Sec 1) : 2023/IEC 60092-101 : 2018 Electrical installations in ships — Specification: Part 1 General, Section 1 Definitions and general requirements (*second revision*)	Identical
IEC 60092-201 Electrical installations in ships — Part 201: System design — General	IS 10242 (Part 2/Sec 1) : 2023/ IEC 60092-201 : 2019 Electrical installation in ships — Specification: Part 2 System design, Section 1 General (*first revision*)	Identical
IEC 60092-350 Electrical installations in ships — Part 350: Shipboard power cables — General construction and test requirements	IS 10242 (Part 3/Sec 10) : 2023/ IEC 60092-350 : 2020 Electrical installation in ships — Specification: Part 3 Equipment, Section 10 General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications (*first revision*)	Identical
IEC 60092-351 Electrical installations in ships — Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables	IS 10242 (Part 3/Sec 11) : 1986 Specification for electrical installations in ships: Part 3 Equipment, Section 11 Insulating materials for shipboard power cables	Technically Equivalent

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60092-353 + AMD 1 : 2001 Electrical installations in ships — Part 353: Single and multicore nonradial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV	IS 10242 (Part 3/Sec 13) : 2023/ IEC 60092-353 : 2016 Electrical installation in ships — Specification: Part 3 Equipment, Section 13 Power Cables for Rated Voltages 1 kV and 3 kV (*first revision*)	Identical
IEC 60092-359 Electrical installations in ships — Part 359: Sheathing materials for shipboard power and telecommunication cables	IS 10242 (Part 3/Sec 19) : 1990 Electrical installation in ships: Part 3 Equipment, Section 19 Sheathing materials for telecomunication and power shipboard cables — Specification	Technically Equivalent
IEC 60092-376 Electrical installations in ships — Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)	IS 10242 (Part 3/Sec26) : 2023/ IEC 60092-376 : 2017 Electrical installation in ships — specification: Part 3 Equipment: Section 26 Cables for control and instrumentation circuits 150-250 V (300 V) (*first revision*)	Identical
IEC 60228 : 2004 Conductors of insulated cables	IS 8130 : 2013 Conductors for insulated electric cables and flexible cords — Specification (*second revision*)	Technically Equivalent
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	IS 16246 : 2015 Elastomer insulated cables with limited circuit integrity when affected by fire — Specification	Technically Equivalent
IEC 60533 : 1999 Electrical and electronic installations in ships — Electromagnetic compatibility.	IS 14479 : 1998 Electrotechnical compatibility of electrical and electronic installations in ships — Specification	Technically Equivalent
IEC 60684-2 : 2003 + AMD 1 : 2003 Flexible insulating sleeving — Part 2: Methods of test	IS 17048 : 2018 Halogen free flame retardant (HFFR) cables for working voltages up to and including 1 100 Volts — Specification	Technically Equivalent

The Committee has reviewed the provisions of the following International Standards referred in this adopted standard and decided that they are acceptable for use in conjunction with this standard.

International Standard	*Title*
IEC 60092-203	Electrical installations in ships — Part 203: System design — Acoustic and optical signals
IEC 60092-354	Electrical installations in ships — Part 354: Single and three-core power cables with extruded solid insulation for rated voltages 6 kV (Um = 7,2 kV); up to 30 kV (Um = 36 kV)

International Standard	*Title*
IEC 60287 (all parts)	Electric cables — Calculation of the current rating
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 60702-1 : 2002	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V
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 + AMD 1 : 1997	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
IEC 61034-2 : 2005	Measurement of smoke density of cables burning under defined conditions — Test procedure and requirements

Only the English language text has been retained while adopting it in this Indian Standard, and as such, the page numbers given here are not the same as in the IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding of numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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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.

Indian Standard

ELECTRICAL INSTALLATION IN SHIPS — SPECIFICATION

PART 3 EQUIPMENT

SECTION 12 CHOICE AND INSTALLATION OF ELECTRICAL CABLES

(First Revision)

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

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*

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_o/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

3.2.2 Control and instrumentation cables

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

In some instances for conductor sizes 1,5 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 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) mm²	Minimum cross-section of earth conductor
1.	i) Insulated earth conductor in cable for fixed installation. 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.	$Q \leq 16$	Q
		$Q > 16$	50 % of the current-carrying conductor, but not less than 16 mm²
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 mm²
		$2{,}5 < Q \leq 6$	1,5 mm²
		$Q > 6$	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 mm² for stranded earthing connection or 2,5 mm² for unstranded earthing connection
		$2{,}5 < Q \leq 120$	50 % of current-carrying conductor, but not less than 4 mm²
		$Q > 120$	70 mm²
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 mm²

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 (mm^2);

  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:

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

  where

  I is the current carrying capacity (A);

  A is the nominal cross-sectional area of conductor (mm^2);

  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.

3.3.4 Correction factors for different ambient air temperatures.

The current-carrying capacities tabulated in Annexes A and B assume a reference ambient air temperature of 45 °C. This temperature is generally applicable to insulated conductors and cables in any kind of ship and for navigation in any climate, irrespective of the method of installation.

Where the ambient temperature in the intended location of the insulated conductors or cables differs from the reference ambient temperature, the appropriate correction factor specified in Table 3 shall be applied to the values of current-carrying capacity set out in Annexes A and B

NOTE The air temperature around the cables can be higher than 45 °C when, for instance, a cable is wholly or partly installed in spaces or compartments where heat is produced or due to heat transfer.

The correction factors in Table 3 do not take account of the increase in temperature, if any, due to solar or other infrared radiation. Where the cables or insulated conductors are subject to such radiation, the current-carrying capacity shall be derived by the methods specified in IEC 60287.

Table 3 – Correction factor for various ambient air temperatures
(Reference ambient temperature of 45 °C)

Maximum rated conductor temperature °C	Correction factors for ambient air temperature of										
	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	75 °C	80 °C	85 °C
60	1,29	1,15	1,00	0,82	-	-	-	-	-	-	-
65	1,22	1,12	1,00	0,87	0,71	-	-	-	-	-	-
70	1,18	1,10	1,00	0,89	0,77	0,63	-	-	-	-	-
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	-	-	-	-
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53	-	-	-
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	-	-
90	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	-
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

3.3.5 Correction factors for short time duty

If a cable is intended to supply a single motor or equipment operating for periods of half an hour or one hour, its current rating, as given in the relevant table (see Annexes A and B), may be increased using the relevant correction factors obtained from Figure 1. These correction factors are only applicable if the intermediate periods of rests are longer than the critical duration (which is equal to three times the time constant of the cable), obtained from Figure 2, as a function of the cable diameter.

NOTE 1 The correction factors given in Figure 1 are approximate and depend mainly upon the diameter of the cable. In general, the half-an-hour service is applicable to mooring winches, windlasses, heavy cargo winches and bowthrusters. The half-an-hour rating might not be adequate for automatic tensioning mooring winches and bowthrusters of specialised vessels.

NOTE 2 For cables supplying a single motor or other equipment intended to operate in an intermittent service, as is generally the case for cargo winches (except heavy cargo winches), engine room cranes and similar devices, the current ratings as given in Annexes A and B may be increased by applying the correction factor obtained from Figure 3.

NOTE 3 The correction factor given in Figure 3 has been calculated for periods of 10 min, of which 4 min are with a constant load and 6 min without load.

3.3.6 Correction Factors for Cable Grouping

In the case of a group of insulated conductors or cables the current carrying capacities tabulated are subjected to the group correction factors given in the relevant annex.

The group correction factors are applicable to groups of insulated conductors or cables having the same maximum operating temperature.

For groups containing cables or insulated conductors having different maximum operating temperatures, the current carrying capacity of all the cables or insulated conductors in the group shall be based on that of the lowest maximum rated conductor temperature of any cable in the group together with the appropriate group correction factor.

Where operating conditions are known, and a cable or insulated conductor is not expected to carry a current greater than 30 % of its calculated grouped rating, it can be ignored for the purpose of obtaining a correction factor for the rest of the group. Also in the case of cables not being loaded simultaneously, consideration of the actual loading appertaining is permitted.

NOTE Cables are said to be bunched when two or more are contained within a single conduit, trunking or duct, or, if not enclosed, are not separated from each other.

3.4 Voltage drop

In the absence of specific design limits or limits set by a regulatory body, the cross-sectional areas of conductors shall be so determined that when the conductors are carrying the maximum current under normal conditions of service, the drop in voltage from the main or emergency switchboard bus-bars to any and every point on the installation does not exceed the limitation given in Clause 36 of IEC 60092-201.

NOTE 1 For supplies from batteries with a voltage not exceeding 50 V, the maximum permitted value of the voltage drop may be increased by 10 %.

NOTE 2 For navigation lights it may be necessary to limit voltage drops to lower values in order to maintain required lighting output and colour.

NOTE 3 The values of voltage drop are applicable under normal steady conditions. Under special conditions of short duration, such as motor starting, higher voltage drops may be accepted provided the installation is capable of withstanding the effects of these higher transient voltage drops or dips.

3.5 Estimation of lighting loads

For the purpose of determining sizes of conductors in lighting circuits, the assessment of the current to be carried shall be made on the basis that every lampholder is deemed to require a current equivalent to the maximum load likely to be connected to it. This shall be assumed to be at least 100 W; except that, where the lighting fitting is so constructed so as to only take a lamp rated at less than 100 W, the current rating shall be assessed accordingly.

Each lighting socket-outlet will count for two lighting points.

3.6 Parallel connection of cables

The current carrying capacity of cables connected in parallel is the sum of the current ratings of all parallel conductors but the cables must have equal impedance, equal cross-section, equal maximum permissible conductor temperatures and follow substantially identical routing or be installed in close proximity. Connections in parallel are only permitted for cross-sections of 10 mm^2 or above. When equal impedance can not be assured, a correction factor of 0,9 shall be applied to the current carrying capacity.

3.7 Separation of circuits

Separate cables are to be used for all circuits requiring individual short-circuit or overcurrent protection, with the exception of the following:

-A control circuit which is branched off from its main circuit (e.g. for an electric motor) may be carried in the same cable as the main circuit provided the main circuit and the subsidiary control circuit are controlled by a common isolator.

-Non essential circuits with voltages not exceeding the “safety voltage” as defined in IEC 60092-101. Also consideration shall be given to fire performance characteristics and electromagnetic interference – see 3.14 and 3.16 respectively.

3.8 Short circuit capacity (withstand capability).

Cables and their insulated conductors shall be capable of withstanding the mechanical and thermal effects of the maximum short circuit current which can flow in any part of the circuit in which they are installed, taking into consideration not only the time/current characteristics of the circuit protective device, but also the peak value of the prospective short circuit current during the first half cycle. Further information is given in IEC 60724 and IEC 60986.

3.9 Conductor

All conductor configurations shall be as listed in IEC 60228.

Stranded copper class 2 conductors or class 5 conductors are recommended for general use in fixed installation systems. The use of class 5 conductors does not imply ‘flexible cables’ but the use is permitted to ease the installation of cables in areas involving tight bending radii or high vibration

Certain cable standards for specific applications specify solid wire (class 1) for conductors. Where these are used, due consideration shall be given to the possible effects of vibration.

NOTE When cables are subject to continuous flexing the advice of the manufacture shall be sought.

3.10 Insulation material

The materials for use as conductor insulation shall be selected from one of those listed in IEC 60092-351. The rated operating temperature of the insulating material selected shall be at least 10 °C higher than the maximum ambient temperature likely to exist, or to be produced, in the space where the cable is installed.

NOTE The construction of a cable can significantly influence the conductor operating temperature and this may be limited to a temperature below that of the thermal rating of the insulation.

3.11 Screen, core screen or shield

The construction of the screen, core screen or shield shall be selected from the cables identified in the parts listed in 3.1.

3.12 Sheathing material

The materials for use as sheathing shall be selected from one of those listed in IEC 60092-359: Consideration shall also be given to fluid resistance for cables installed where, for example, water condensation or harmful vapours (including oil vapour) may be present. In this instance the cables shall meet the appropriate fluid resistance requirements.

In choosing different types of over sheathing as a protective cover, consideration shall also be given to the mechanical actions to which each cable may be subjected during installation and in service. If the mechanical strength of the over sheath is considered insufficient, the cable shall be fitted in pipes or conduits or trunking or be otherwise protected (see 3.21).

Also consideration shall be given to the fire performance characteristics given in 3.14

3.13 Metallic braid or armour.

The construction of the metallic braid or armour shall be in accordance with IEC 60092-350 and the applicable product standard.

3.14 Fire performance

All cables or insulated wiring shall meet the requirements for flame spread as given in:

- IEC 60332-1-2
- IEC 60332-3-22.
- Unless otherwise given in the individual product standard the cables shall be tested in a touching configuration (using a 300 mm ladder) in multiple layers if required to achieve the 7 l/m loading of the ladder.

NOTE 1 It cannot be assumed that, because a cable or an insulated wire meets the requirements of IEC 60332-1-2, a bunch of similar cables or insulated wires will behave in a similar manner. The flame-spread performance of bunched cables is assessed by the requirements of IEC 60332-3-22. This performance requirement (i.e. for cables mounted vertically in a touching formation) has been chosen to best reflect the installation conditions generally observed on board ships. Experience has shown that the test for the flame spread of cables installed vertically is adequate for horizontal installations, all other parameters being generally the same.

NOTE 2 Further information is given in IEC 60332-3-22.

NOTE 3 Additional protection may be provided by the use of fire stops – see Annex C.

For systems required to maintain electrical circuit integrity under fire conditions, e.g. for fire alarm, fire detection, fire extinguishing services, remote stopping and similar control circuits, the cables shall meet the requirements of IEC 60331-21 or IEC 60331-31 as given in the appropriate individual product standard. Unless otherwise given in the individual product standard the flame application time shall be at least 90 min at the temperature specified in the relevant standard. This requirement is not applicable where the systems are of a self-monitoring type, failing to safety or are duplicated, or routed away from high fire risk areas. – See item o) of 3.15.

NOTE 4 The use of suitable installation materials is essential for cables that are required to maintain electrical circuit integrity under fire conditions.

Due consideration shall be given to the requirements for smoke emission, acid gas evolution and halogen content for cables installed in accommodation spaces, and passenger areas. Where applicable, the cables shall be evaluated in accordance with the following test methods:

- IEC 61034-2;
- IEC 60754-1;
- IEC 60754-2;
- IEC 60684-2.

Unless otherwise given in the individual product standard the cables shall meet the requirements given in the test specification.

3.15 Cable runs

Cable run requirements are as follows.

a) Cable runs shall be selected so as to be as far as possible straight and accessible. Where cables are installed behind panelling, all connections shall be readily accessible and the location of concealed connection boxes shall be indicated.

b) In the choice of cable runs, account shall be taken of the need for protection against destructive pests or rodents.

c) Cables having insulating materials with different maximum permissible rated conductor temperatures shall not be bunched in a common clip, cable transit, conduit, trunking or duct. Where this is impracticable, the cables shall be rated so that no cable reaches a temperature higher than the lowest rated conductor temperature within the bunch.

d) Cables having a protective covering which may damage the covering of more vulnerable cables shall not be bunched with the latter in a common clip, gland, conduit, trunking or duct.

e) Cables having a bare metallic sheath or braid or armour shall be installed in such a way that corrosion (e.g. galvanic or electrolytic) on contact with other metals, is prevented.

f) Cable runs shall be selected so as to avoid action from condensed moisture or drip. Unless unavoidable, cables shall not be located behind or embedded in structural heat insulation.

g) Cables shall, as far as possible, be remote from sources of heat such as boilers, hot pipes, banks of resistors, etc., and protected from avoidable risks of mechanical damage. Where installation of cables near sources of heat cannot be avoided, and where there is consequently a risk of damage to the cables by heat, suitable shields shall be installed, or other precautions to avoid over heating shall be taken, for example, use of special ventilation, installation of heat insulation materials, or use of special heat resisting cables. Cables shall not be located in cargo tanks, ballast tanks, fuel tanks, or water tanks except to supply equipment and instrumentation specifically designed for such locations and whose functions require them to be installed in the tank. Such equipment may include submerged cargo pumps and associated control devices, cargo monitoring, and underwater navigation systems.

h) Cables shall not be installed across expansion joints. If however, it is unavoidable, a loop of cable having a length proportional to the expansion of the joint shall be provided. The minimum internal radius of the loop during operation shall never be less than twelve times the external diameter of the cable.

i) The flame spread performance of cables installed in bunches can be affected by a number of factors including the method of installation see 3.14 – Further guidance is given in IEC 60332-3-22.

j) In the case of essential electrical equipment for which it is mandatory to have at least two supplies, for example, steering gear installations, the supply and any associated control cables shall follow different routes, which, as far as practicable, shall be separated both vertically and horizontally. In the case of duplicated essential electrical equipment, the supply and any associated control cables shall follow different routes, which shall be separated both vertically and horizontally as far as practicable.

   NOTE 1 Systems which could operate as each other's stand-by for an essential function, such as an engine room telegraph together with an engine bridge control system, shall in this respect be dealt with likewise.

   NOTE 2 When the main switchboard is located in a separate and enclosed compartment, such as an engine control room, this clause is not applicable to the equipment and cables installed in this compartment.

k) Where it is required to divide a ship into fire zones (such as is generally the case of passenger ships), cable runs shall be so arranged that a fire in any main vertical fire zone will not affect operation of essential services in any other such zone. This requirement will be met if main and emergency cables passing through any zone are separated both vertically and horizontally as widely as is practicable and do not pass through the same horizontal zone. The cables shall be capable of maintaining circuit integrity in the event of fire – see item o)

l) Cables and wiring serving essential or emergency systems shall so far as practicable be routed clear of galleys, laundries, machinery spaces and their casings and other high fire risk areas, except for supplying equipment in those spaces. They shall be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

m) When it is essential that a cable shall function for some time during a fire and it is unavoidable that the cable for such a circuit is routed through a high risk area it shall meet the requirements of 3.14.

n) Cables for intrinsically safe circuits shall be bunched together and routed separately from power or control cables. The outer sheath of the cable shall be coloured blue or alternatively black with a blue stripe(s). The stripe(s) shall be applied such that it is clearly visible when the installed cable is exposed.

   NOTE 3 A sheath coloured black with a blue stripe has been accepted by the national authorities of some countries.

o) In respect of the prevention of fire damage to cables, special attention shall be given to the protection of main cable routes for essential circuits as, for example, between machinery spaces and the navigation bridge area, taking into account the fire risk existing in accommodation spaces.

   NOTE 4 Machinery spaces of category A according to SOLAS Convention 1974 and its amendments, and their casings, galleys and laundries are to be included among high fire risk areas see IEC 60092-101.

p) Cable penetrations shall be arranged so as to maintain the fire integrity of the ship. See Annex C for further details.

3.16 Cable installation methods in relation to electromagnetic interference

In order to avoid as much as possible the effects of unwanted electromagnetic interference, attention shall be given to IEC 60533. This is of particular importance for the installation of cables in the vicinity of radio equipment and for the installation of cables belonging to sensitive electronic control and monitoring systems.

3.17 Mechanical protection

In situations where there is a risk of mechanical abuse, cables shall be enclosed in suitable conduits or casings, unless the cable covering (for example armour or sheath) provides adequate protection.

In situations where there is an exceptional risk of mechanical damage, for example in holds, storage, cargo spaces etc., cables shall be protected by steel casing, trunking or conduits, even when armoured, if the ship’s structure or attached parts do not afford sufficient protection for the cables.

Metal casing used for mechanical protection of cables shall be efficiently protected against corrosion.

3.17.1 Earthing of metal coverings and of mechanical protection of cables

All metal coverings of cables shall be electrically connected to the metal hull of the ship at both ends except in so far as the provisions given in this clause apply. Single point earthing is permitted for final circuits (at the supply end), single core cables and in those installations (control and instrumentation cables, mineral insulated cables, intrinsically safe circuits, control circuits, etc.) where it is required for technical or security reasons, if any.

The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The glands shall be firmly attached to, and in effective electrical contact with, a metal structure earthed in accordance with this standard.

The electrical continuity of all metal coverings throughout the length of the cables, particularly at joints and tappings, shall be ensured.

Metal casings, pipes and conduits or trunking shall be effectively earthed.

Equipment earthing connections shall be carried out with conductors having cross-sectional areas (see Table 2) related to the cross sectional area of current carrying conductor (see Tables A.1– A.5, or by equivalent means, such as metal clamps gripping the metal covering of the cable and connected to the metal hull of the ship.

The metal sheath (covering), armour or braid of a cable may be used as the only means of earthing if the earth loop impedance is low enough to ensure effective operation of the device(s) intended to protect the circuit. This is additional to the requirements of IEC 60092-350 and Table 2 relating to cross sectional area of the braid.

NOTE 1 In some countries it is prohibited to use the cable armour as an earthing conductor.

NOTE 2 Careful consideration needs to be given to possible adverse effects due to corrosion, see 3.15.

3.18 Bending radius

The internal bending radius for the installation of cables shall be as recommended by the manufacturer according to the type of cable chosen, and shall not be less than the values given in Tables 4 and 5.

Table 4 – Bending radii for cables rated up to 1,8/3 kV

Cable construction		Overall diameter of cable (*D*)	Minimum internal radius of bend
Insulation	**Covering**		
Thermoplastic or thermosetting with circular copper conductors	Unarmoured or unbraided	≤25 mm	4 *D* [a]
		>25 mm	6 *D*
	Metal braid screened or armoured	Any	6 *D*
	Metal wire armoured Metal tape armoured or metal- sheathed	Any	6 *D*
	Composite polyester/metal laminate tape screened units or collective tape screening	Any	8 *D*
Thermoplastic or thermosetting with sector shaped copper conductors	Any	Any	8 *D*
Mineral	Hard metal sheathed	Any	6 *D*

[a] 6*D* for defined circuit integrity

Table 4A – Bending radii for cables rated at 3,6/6,0(7,2) kV and above

Cable construction	Overall diameter of cable (*D*)	Minimum internal radius of bend
Single Core Cable	Any	12 *D*
3 – Core cables	Any	9 *D*

3.19 Supports and fixing

With the exception of cables for portable appliances and those installed in pipes, conduits, trunkings or special casings, cables shall be fixed by means of clips, saddles or straps of suitable material which if ignited, shall not contribute to any spread of flame along the cables or insulated wire. The material shall have a surface area sufficiently large and be shaped such that the cables remain tight without their coverings being damaged.

The distances between supports shall be chosen according to the type of cable and the probability of vibration. It shall not exceed 400 mm for a horizontal cable run where the cables are laid on cable supports in the form of tray plates, separate support brackets or hanger ladders. The spacing between the fixing points may be up to 900 mm, provided that there are supports with maximum spacing as specified above. This exemption shall not apply to cable runs along weather decks, when the cable run is arranged so that the cables can be subjected to forces by water washing over the deck.

NOTE 1 When designing a cable support system for single core cables consideration shall also be given to the effects of electrodynamic forces developing on the occurrence of a short circuit (see 3.8). The distances between cable supports given above are not necessarily adequate for these forces.

NOTE 2 Cables with class 5 conductors may require additional support to prevent sagging

The supports and the corresponding accessories shall be robust and shall be of corrosion resistant material or suitably treated before erection to resist corrosion.

NOTE 3 Cable clips or straps made from a material other than metal may be used. Requirements concerning the characteristics of the material are under consideration.

When cables are fixed by means of non-metallic clips or straps, and are not laid on top of horizontal cable trays or cable supports, suitable metal cable clips or saddles shall be added at regular distances not greater than 1 m in order to prevent the release of cables during a fire. This also applies to the fixing of non-metallic conduits or pipes.

Cable clips or straps used to support cable for use in high fire risk areas and safety escape routes shall be metallic – see 3.15

3.20 Cables penetrating bulkheads and decks

Penetration of watertight decks and bulkheads shall be effected in a watertight manner. Either individual stuffing glands or boxes containing several cables and filled with a flame retardant packing shall be used for this purpose. Whichever type of cable is used, the glands, transits, or boxes and their packing shall be such that the assembly meets the requirements of the appropriate approval or regulatory authority.

NOTE Care shall be taken in choosing packings, to avoid cables being adversely affected (e.g. by high temperature arising from the pouring of the compound, chemical reaction, etc.).

Cables passing through decks shall be protected to a suitable height above the deck.

If cables have to pass through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes shall be fitted with glands or bushings of any suitable material.

The choice of the materials used for glands and bushings shall be such that there is no risk of corrosion or damage to the cables or to the ship’s structural materials.

Vertical trunking for electrical cables shall be so constructed as not to afford passage of fire from one between deck or compartment to another.

Penetration of decks and bulkheads, which are required to have some degree of fire integrity, shall be so effected as to ensure that the required degree of fire integrity is not impaired.

The choice of type of cable constructions, which run through penetrations, shall be chosen so that the required degree of sealing of the gland is not impaired.

3.21 Installation in metallic pipes or conduits or trunking

When cables are installed in metal tubes, conduits or trunking, the following precautions shall be observed.

The pipes, conduits or trunking shall be suitably smooth on the interior and protected against corrosion.

The pipes or conduits or trunking shall have their ends shaped or bushed in such a way so as not to damage the cable covering.

The pipes or conduits or trunking shall have such internal dimensions and radius of bend that will permit the easy drawing in and out of the cables which they are to contain: the internal radius bend shall be not less than those permitted for cables (see 3.18) and, for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe.

Pipes, conduits and trunking shall be so arranged that water cannot accumulate inside them (account being taken of possible condensation).

The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional area of the pipe or conduit or trunking) shall not be greater than 0,4.

If necessary, ventilating openings shall be provided, preferably at the highest and lowest points, so as to permit air circulation and to obviate the possibility of water accumulating at any part of the pipe, conduit or trunking run. These ventilation openings shall not be made if their inclusion will increase the fire risk.

If there is reason to fear that a tube may break because of its length, appropriate expansion joints shall be provided. This might be the case when cable pipes are fitted along weather decks.

Where cables are to be drawn into pipes or conduits or trunking, draw boxes shall be installed where necessary in order to ensure that the cables are not damaged during installation.

3.22 Installation in non-metallic pipes, conduits, trunking, ducts or capping and casing

Cables may be installed in non-metallic pipes, conduits, trunking, ducts or casings either on surface or concealed behind ceilings or panelling, provided the following precautions are observed.

If the fixing of capping is by means of screws, they shall be of non-oxidising materials arranged so as not to damage the cables. The capping shall be readily accessible.

Non-metallic pipes, conduits, trunkings, ducts or cappings and casings shall, if ignited, limited the spread of flame in accordance with IEC 60092-101 and shall be properly secured.

The resistance to the spread of flame along the cables shall not be significantly impaired by the use of such pipes, conduits, trunkings, ducts or capping and casings, and their paints or coatings.

Cables shall be fixed if necessary with clips as described in 3.19 and the precautions recommended in items c) and d) of 3.15, for metallic protection, shall also be observed for installation in non-metallic casings.

3.23 Installation in battery compartments

Installation of cables in rooms assigned to batteries shall be avoided as far as possible (see IEC 60092-401). Where such an installation is necessary, the cables shall have a protective covering resistant to the vapours developed by the electrolyte and the bulkhead penetration shall be gas tight.

3.24 Installation in refrigeration spaces

Cables to be installed in refrigeration spaces shall be protected against mechanical damage – see also 3.12. Cables insulated or sheathed with PVC shall not be used in refrigerated spaces unless the PVC compounds are appropriate to the low temperature expected.

If the armour is not corrosion resisting, it shall be protected against corrosion by a moisture resisting and low temperature resisting covering.

Care shall be taken to avoid the possibility of electrolytic action if the refrigeration chamber has an aluminium facing.

3.25 Tensile stress

Cables shall be so installed that the tensile stress applied to them either by reason of their own weight or for any other reason is minimised.

The mechanical strength of conductors shall be sufficient for the installation and working conditions and the cross sectional area of the conductor shall not be less than 0,5 mm^2. These precautions are particularly important for cables of small cross-section and for cables on vertical runs, or in vertical pipes. These cables shall be suitably supported.

3.26 Special precautions for single core cables for a.c. wiring

AC wiring shall be carried out, as far as possible, in twin or multicore cables. When, however, it is necessary to use single core cables for circuits rated in excess of 20 A, the following precautions shall be observed:

a) The cables should either be non-armoured or they should be armoured with non- magnetic material. In order to avoid current loops, the metallic screen should be earthed at one point only. The free end of the metallic screen shall be sufficiently insulated to protect against high voltages induced by short circuit currents.
b) Conductors belonging to the same circuit shall be contained within the same pipe, conduit or trunking, or the clamps, which fix them, shall include all the phases, unless they are made of non-magnetic material.
c) When installing two, three or four single core cables forming respectively single phase circuits, three phase circuits or three phase and neutral circuits, the cables shall as far as possible be in contact with one another. In every case, the distance measured between the external covering of two adjacent cables shall not be greater than one cable diameter (D_e).
d) When single core cables having a current rating greater than 250 A must be installed near a steel bulkhead, the clearance between the cables and the bulkhead shall be at least 50 mm, unless the cables belonging to the same a.c. circuit are installed in trefoil formation.

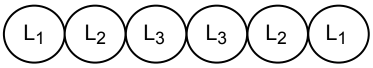
e) Magnetic material shall not be used between single core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit shall pass through a plate or gland, so made that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material shall be not less than 50 mm, unless the cables belonging to the same a.c. circuit are installed in trefoil formation.

f) In order to try to equalise the impedance of three phase circuits (of considerable length, or consisting of single core cables of a conductor cross-section of 185 mm^2 or larger), a transposition of the phases shall be effected at intervals not exceeding 15 m. The above precautions are, however, not necessary when the cables are installed in trefoil formation.

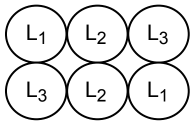
g) In circuits involving several single core cables in parallel per phase, all cables shall follow the same route and have the same cross-sectional area.

NOTE Cables in d.c. systems with superimposed a.c. voltage or current can create the same problems as for a.c. systems. Also in those situations, special precautions have to be taken.

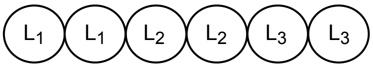
Further, the cables pertaining to the same phase shall be as far as practicable alternated with those of the other phases so that unequal division of the current is avoided. For instance, in case of two cables per phase, the correct dispositions are as follows:



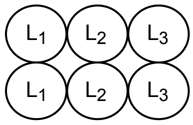
or



Whereas the following dispositions are unacceptable:



or



3.27 Cable ends

In general, connections and terminations to all conductors must retain the original electrical, mechanical, resistance to flame spread, and where necessary, limitation of circuit integrity in case of fire properties of the cable. All connecting devices must be suitable for copper stranded conductors.

Where mechanical terminations are not used, the ends of all cable conductors shall be fitted with soldering sockets or compression type sockets of sufficient size to contain all the strands of the conductor. Where soldering is adopted, corrosive fluxes shall not be used. All protective coverings shall be removed for at least 13 mm from the ends of the insulation but not more than necessary. For mineral cables see below.

Cable sockets and connecting terminals shall be of such design and dimensions that the maximum current likely to flow through them will not produce heat which would be injurious to the insulation. In general, the temperature shall not exceed that allowed for the cable in relation to the insulation.

The fixing of conductors in terminals (including soldered joints), at joints and at tappings, shall withstand the thermal and dynamic effects of short circuit currents.

When required, cable ends shall be marked for identification.

The ends of mineral insulated cables shall be prepared in accordance with the instructions issued by the manufacturers of these cables.

NOTE The ends of unused conductors in multicore cables should be suitably treated, either by capping or connecting to earth, so that the requirements of the particular system or installation are achieved.

3.28 Joints and tappings (branch circuits)

Cable runs shall not normally include joints. Cable joints are permitted under the following conditions:

A cable installed in a structural sub-assembly may be spliced to a cable installed in another structural sub-assembly to facilitate modular construction techniques.

For a vessel receiving alterations, a cable may be spliced to extend a circuit

A cable of exceptional length may be spliced to facilitate its installation

A cable may be spliced to replace a damaged section when the remainder of the cable is determined to be in good mechanical and electrical condition.

Spliced connections should be accessible.

A method of preparation of a spliced connection is given in informative Annex D

Propulsion cables and cables in hazardous locations should not be spliced.

A cable connected in a junction box is not considered to be a spliced connection.

Joints and tappings shall be clearly marked to identify the cable(s) and core(s).

3.29 Joint boxes

Live parts shall be mounted on durable flame-retardant moisture resistant material, having permanently high dielectric strength and high insulation resistance.

The live parts shall be arranged by suitable spacing, or shielding with flame retardant insulating material, so that a short circuit cannot readily occur between conductors of different polarity or between conductors and earthed metal.

Joint boxes shall be made of flame retarded material. The ability of the joint box material to limit the spread of flame shall be at least that of the cables entering it.

Joint boxes shall be clearly identified defining their function and voltage.

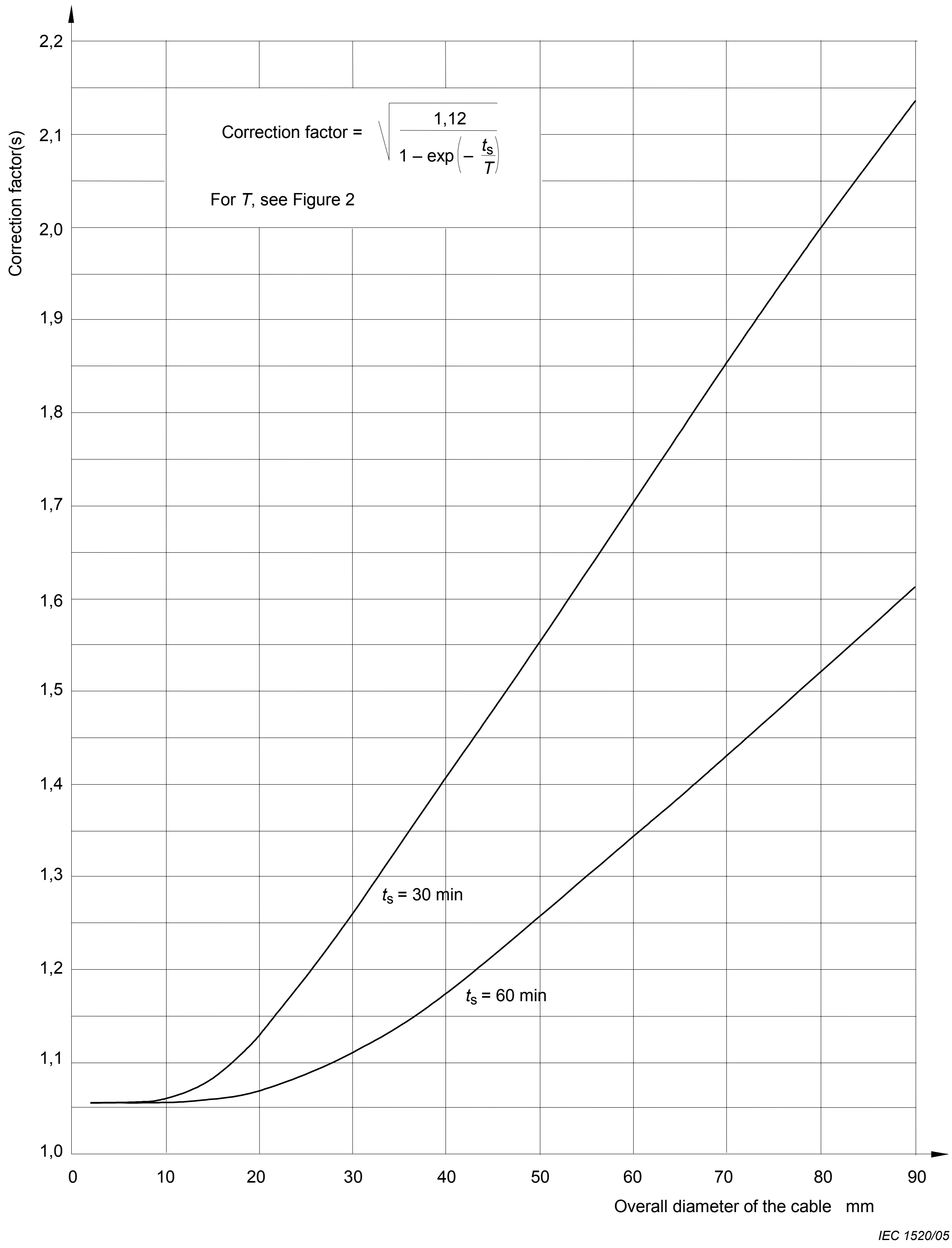


Figure 1 – Correction factors for half-hour and one hour service

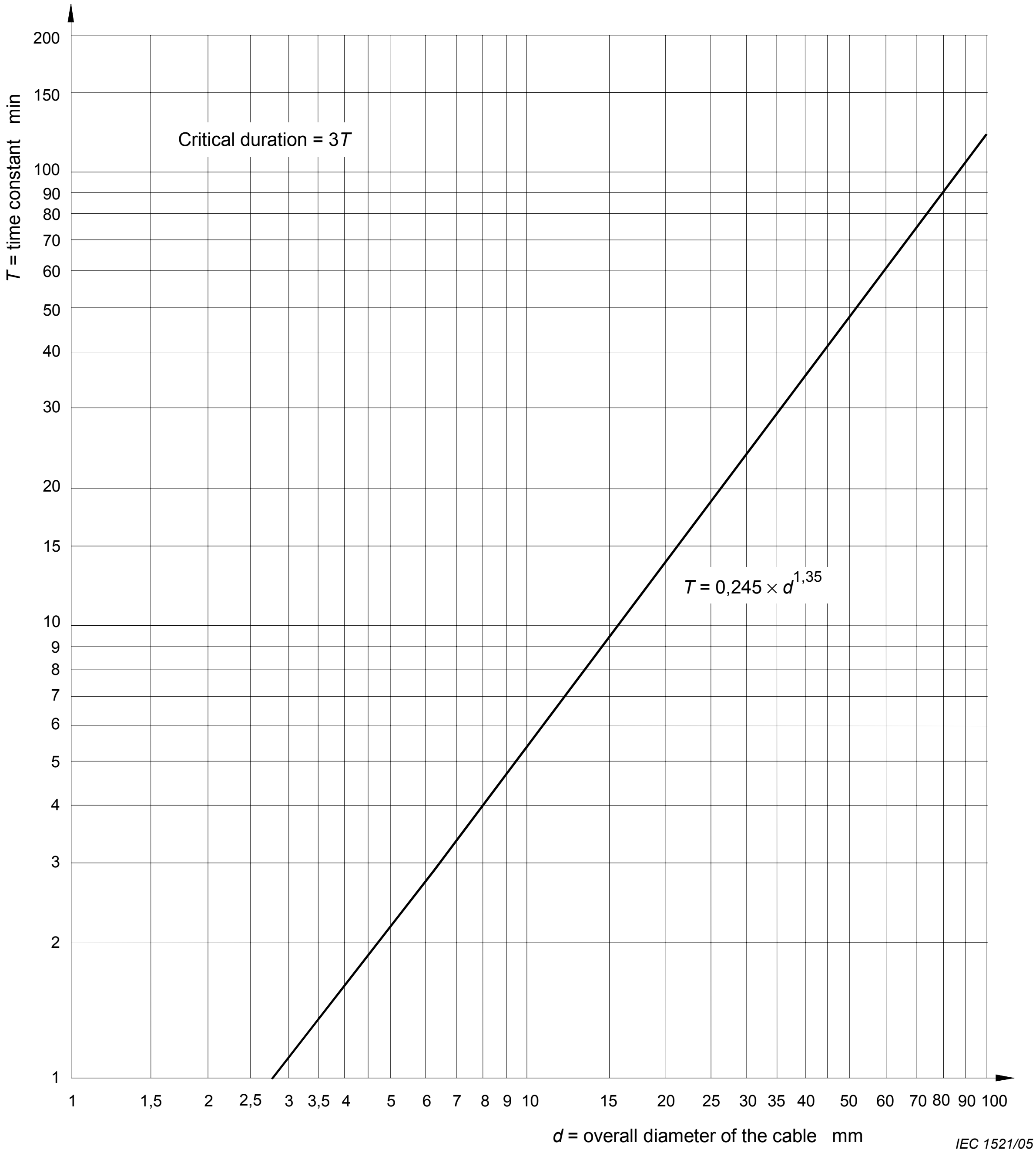
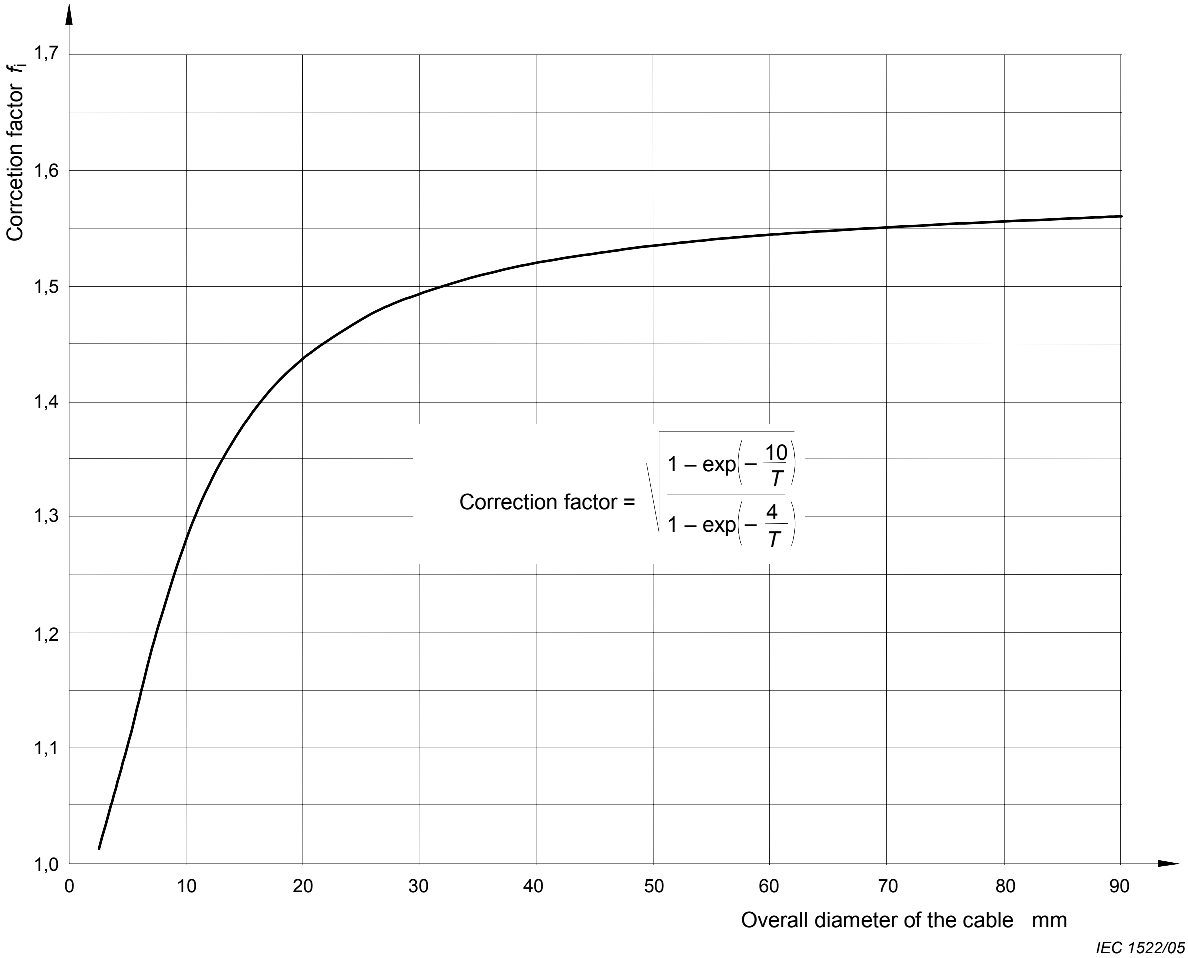


Figure 2 – Time constant of cables



Intermittence period = 10 min Intermittence ratio = 40 %

Figure 3 – Correction factor for intermittent service

Annex A
(informative)

Tabulated current carrying capacities – Defined installations

A.1 General

The current ratings in Tables A.1 to A.5 are applicable for d.c. and a.c. with a nominal frequency of 50 Hz or 60 Hz. For higher frequencies, the current rating shall be calculated with an appropriate method (e.g. IEC 60287).

NOTE 1 The current ratings in Tables A.1 to A.5 are applicable, with fair approximation, whatever is the type of covering (e.g. both armoured and unarmoured cables). Where the armour, screens or metallic sheaths of single core cables are bonded at both ends of a run, the circulating currents in the metallic layers will reduce the current rating of the cables. The extent of the reduction will depend on the resistance of the metallic layer. In such cases the current rating should be calculated for the specific cable type.

NOTE 2 The current ratings in Tables A.1 to A.5 are based on the nominal dimensions of 600/1 000 V cables. Current ratings for higher voltage cables, up to 15 kV, may be up to about 5 % lower than the tabulated values for LV cables.

NOTE 3 The current ratings in Tables A.1 to A.5 are based on class 2 conductors. When using cables with class 5 conductors, users should carefully check the applicable current rating, which may be lower than for cables with the same nominal cross-sectional area of class 2 conductors. See IEC 60228 for references to classes of conductors

A.2 Reference methods of installation

The reference methods are those methods for which the current-carrying capacity has been determined by test or calculation.

For the electrical installations in ships the following reference methods of IEC 60364-5-52 are considered applicable and are presented in Tables A.1 to A.5 (in which 'D_e' is the value of a cable diameter).

NOTE The installation methods A and D as given in IEC 60364-5-52 are not currently used in this standard – however to avoid confusion the other reference notations from that specification have been retained.

– **Reference methods B.1** (insulated conductors in a conduit on a bulkhead) **and B.2** (multi-core cable in a conduit on a bulkhead). These apply to a circuit mounted on a bulkhead so that the gap between the conduit and the surface is less than 0,3 times the conduit diameter. The conduit can be metal or plastic.

– **Reference method C** (single core or multicore cable on a bulkhead). These apply to a cable mounted on a bulkhead so that the gap between the cable and the surface is less than 0,3 times the cable diameter.

– **Reference methods E, F and G** (single-core or multi-core cable in free air). These apply to a cable so supported that the total heat dissipation is not impeded. Heating due to solar radiation and other sources shall be taken into account. Care shall be taken that natural air convection is not impeded. In practice, a clearance between a cable and any adjacent surface of at least 0,3 times the cable external diameter for multicore cables, or one times the cable diameter for single-core cables, is sufficient to permit the use of current carrying capacities appropriate to free air conditions.

NOTE The current carrying capacities in this document are applicable for either metallic or non-metallic bulkheads.

A.3 Other methods of installation

The method of installation for a cable on or under a deck is similar to reference **method C** except that the rating for a cable under a deck is slightly reduced (see Table 8) from the value for a bulkhead or on a deck because of the reduction in natural convection.

The method of installation for cable tray: a perforated tray has a regular pattern of holes so as to facilitate the use of cable fixings. The ratings for cables on perforated trays have been derived from test work utilising trays where the holes occupied 30 % of the area of the base reference **methods E or F**. If the holes occupy less than 30 % of the area of the base the tray is regarded unperforated. This is similar to reference **method C**.

The method of installation for ladder support: this is of a type of construction which offers a minimum of impedance to the airflow around the cables, i.e. supporting metal work under the cables occupies less than 10 % of the plan area – reference **methods E or F**.

The method of installation for cleats and hangers: this type of cable support holds the cable at intervals along its length and permits substantially complete free air around the cable. Reference **methods E, F or G**.

The method of installation for decks (false floors) – cables installed under decks or false floors reference **methods B1** for single core cables and **B2** for multicore cables.

A.4 Correction factors for cable grouping

The current carrying capacities tabulated in Tables A.1 to A.5 shall be subjected to the group correction factors in case of a group of insulated conductors or cables.

The group correction factors are applicable to groups of insulated conductors or cables having the same maximum operating temperature.

For groups containing cables or insulated conductors having different maximum operating temperatures, the current carrying capacity of all the cables or insulated conductors in the group shall be based on that of the lowest maximum rated conductor temperature of any cable in the group together with the appropriate group correction factor.

Where operating conditions are known, and a cable or insulated conductor is not expected to carry a current greater than 30 % of its calculated grouped rating, it can be ignored for the purpose of obtaining a correction factor for the rest of the group. Also in the case of cables not being loaded simultaneously, consideration of the actual loading appertaining is permitted.

NOTE 1 Cables are said to be bunched when two or more are contained within a single conduit, trunking or duct, or, if not enclosed, are not separated from each other

A.4.1 For installation **methods B and C** the current carrying capacities given in Tables A.1 to A.5 relate to single circuits consisting of the following numbers of conductors:

– two insulated conductors or two single-core cables, or one twin-core cable;
– three insulated conductors or three single-core cables, or one three-core cable.

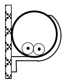
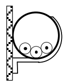
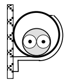
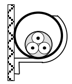
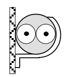
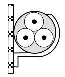
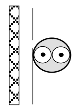
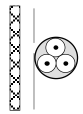
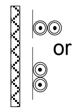
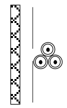
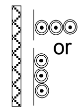
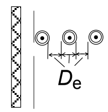
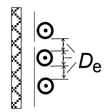
Where more insulated conductors or cables are installed in the same group, the group correction factors specified in table A.6 shall be applied.

NOTE 2 The group correction factors have been calculated on the basis of prolonged steady-state operation at the 100 % load factor for all line conductors. Where the loading is less than 100 % as a result of the conditions of operation of the installation, the group correction factors may be higher.

A.4.2 For installations **methods E and F** on trays with cleats, clamps, etc. current carrying capacities for both single circuits and groups shall be obtained by multiplying the capacities given in tables A.1 to A.5, (for the relevant arrangements of insulated conductors or cables in free air), by the installation and group correction factors given in tables A.6 to A.8.

NOTE 3 Group correction factors have been calculated as averages for the range of conductor sizes, cable types and installations considered. Attention is drawn to the notes under each table. In some instances, a more precise calculation may be desirable.

Table A.1 – Current carrying capacities in amperes – Copper conductor temperature: 60 °C and reference ambient air temperature: 45 °C

Nominal cross-sectional area of conductor mm²	Installation Method												
	Method B1 Insulated conductors or single core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**Method F** Single core cables, touching in free air			**Method G** Single core cables, spaced in free air	
	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors trefoil	Three conductors	Horizontal	Vertical
													
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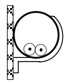
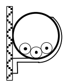
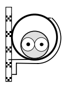
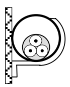
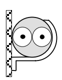
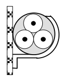
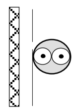
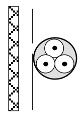
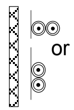
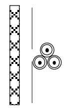
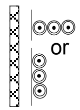
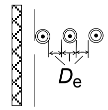
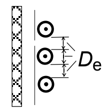
4	19,5	17	18,5	16,5	22	19,5	25	21					
6	25	22	23	21	28	25	31	26					
10	35	31	32	28	38	35	43	37					
16	46	41	42	38	52	46	57	49					
25	62	54	55	49	68	59	73	62	80	67	70	89	79
35	76	67	68	60	84	73	90	77	99	84	87	110	99
50	92	82	81	72	102	88	110	93	120	102	106	134	120
70	117	104	102	91	130	112	142	120	153	132	137	171	155
95	142	126	123	109	157	136	172	145	185	161	168	208	190
120	164	146	142	126	182	158	200	168	215	188	196	242	221
150					210	182	231	195	248	217	227	278	256
185					239	208	265	222	282	249	260	318	293
240					281	246	314	262	333	296	309	375	347
300					323	283	362	303	384	342	358	432	402
400									460	400	420	520	485
500									529	457	481	599	561
630									613	522	552	694	653

**Table A.2 – Current carrying capacities in amperes –
Copper conductor temperature: 70 °C and reference ambient air temperature: 45 °C**

Nominal cross-sectional area of conductor	Installation Method													
	Method B1 Insulated conductors or single core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**Method F** Single core cables, touching in free air			**Method G** Single core cables, spaced in free air	
	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors trefoil	Three conductors	Horizontal	Vertical
mm²													
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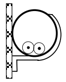
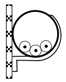
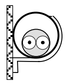
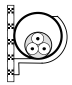
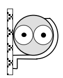
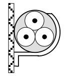
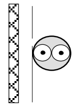
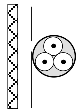
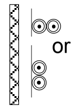
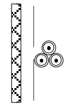
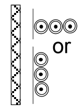
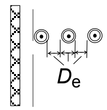
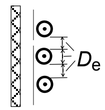
6	32	28	30	27	36	32	40	34					
10	45	40	41	36	50	45	55	47					
16	60	54	55	49	67	60	74	63					
25	80	70	71	63	88	76	94	80	103	87	90	115	103
35	99	87	88	78	109	94	117	100	128	108	113	143	128
50	119	106	105	93	133	114	142	121	155	132	137	173	156
70	152	135	133	118	168	145	183	155	198	171	178	222	201
95	183	164	159	141	204	176	223	188	240	209	217	269	246
120	213	189	183	163	236	205	259	218	278	243	254	313	286
150					272	236	299	252	321	281	294	360	331
185					310	269	343	288	366	323	337	412	379
240					364	318	406	340	431	383	401	486	450
300					419	367	468	393	497	443	464	560	521
400									596	518	544	673	628
500									686	592	623	776	727
630									794	675	715	899	845

**Table A.3 – Current carrying capacities in amperes –
Copper conductors temperature: 85 °C and reference ambient air temperature: 45 °C**

Nominal cross-sectional area of conductor mm²	Installation Method												
	Method B1 Insulated conductors or single core cables in conduit on a wall		**Method B2** Multi-core cable in conduit on a wall		**Method C** Multi-core cables on a wall		**Method E** Multi-core cables in free air		**Method F** Single core cables, touching in free air			**Method G** Single core cables, spaced in free air	
	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors trefoil	Three conductors	Horizontal	Vertical
													
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2,5	25	23	25	21	27	25	30	26					
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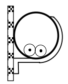
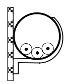
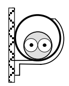
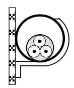
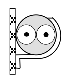
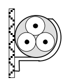
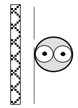
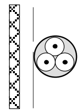
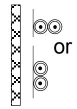
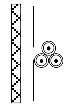
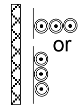
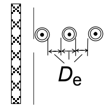
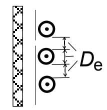
6	44	39	42	36	48	43	52	44					
10	62	54	57	49	66	58	71	62					
16	82	72	75	66	88	79	94	82					
25	109	96	98	86	113	98	122	104	132	111	116	149	132
35	134	118	120	105	140	121	152	130	164	139	144	185	165
50	162	144	144	126	171	147	185	157	198	170	177	226	202
70	207	182	181	159	221	188	237	202	254	220	229	289	261
95	251	221	217	191	269	228	289	244	309	269	280	353	319
120	290	256	250	220	313	264	336	284	358	314	328	410	372
150					362	304	388	327	413	364	380	473	432
185					415	348	444	374	472	418	437	542	496
240					491	410	526	441	557	498	520	640	590
300					568	472	608	509	642	576	604	740	683
400									771	675	712	890	827
500									888	776	818	1 027	959
630									1 028	892	944	1 192	1 117

Table A.4 – Current carrying capacities in amperes – Copper conductors temperature: 90 °C and reference ambient air temperature: 45 °C

Nominal cross-sectional area of conductor	Installation Method												
	Method B1 Insulated conductors or single core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		Method F Single core cables, touching in free air			**Method G** Single core cables, spaced in free air	
	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors trefoil	Three conductors	Horizontal	Vertical
mm²													
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2,5	27	24	26	23	29	26	31	28					
4	37	32	35	30	39	35	43	37					
6	47	42	44	38	50	45	55	47					
10	65	57	60	52	70	62	75	65					
16	87	77	79	70	93	84	100	87					
25	116	102	104	91	120	104	130	110	140	117	123	158	140
35	143	125	127	111	149	128	161	137	174	147	153	197	175
50	172	152	152	134	182	156	196	167	211	180	188	239	214
70	220	193	192	169	234	199	251	214	270	233	243	307	277
95	266	234	231	203	285	242	306	259	328	285	298	374	338
120	308	271	265	233	332	280	357	301	380	333	348	435	395
150					384	323	412	347	438	386	404	502	458
185					440	369	472	397	500	444	464	575	526
240					521	435	558	468	591	528	552	679	626
300					603	501	645	540	681	612	640	785	725
400									818	716	755	944	877
500									942	823	868	1 090	1 017
630									1 091	947	1 001	1 265	1 185

**Table A.5 – Current carrying capacities in amperes –
Copper conductors temperature: 95 °C and Reference ambient air temperature: 45 °C**

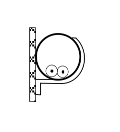
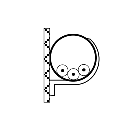
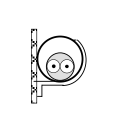
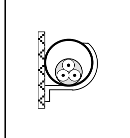
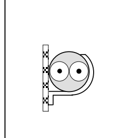
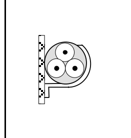
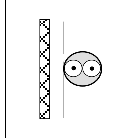
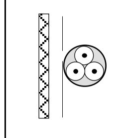
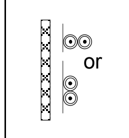
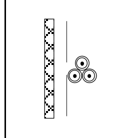
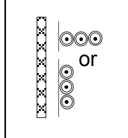
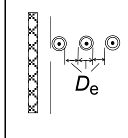
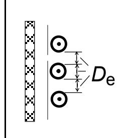
Nominal cross-sectional area of conductor	Installation Method												
	Method B1 Insulated conductors or single core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**Method F** Single core cables, touching in free air			**Method G** Single core cables, spaced in free air	
	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors	Two conductors	Three conductors trefoil	Three conductors	Horizontal	Vertical
mm²													
1,5	21	18	20	18	22	20	24	21					
2,5	28	25	27	24	30	27	33	29					
4	38	34	36	32	41	36	45	38					
6	49	44	46	40	53	47	57	49					
10	68	60	63	55	73	65	78	68					
16	91	80	83	73	97	87	105	91					
25	121	106	108	96	126	108	136	116	147	123	128	166	147
35	149	131	133	116	156	134	168	144	182	154	160	206	183
50	180	159	159	140	190	163	205	175	220	188	197	250	224
70	230	202	201	177	245	208	263	224	282	244	254	321	289
95	278	245	241	212	298	253	320	271	343	298	311	391	354
120	322	284	278	244	348	293	373	315	398	349	364	455	413
150					401	338	430	363	459	404	422	525	480
185					460	386	493	415	523	464	485	602	551
240					545	455	583	490	618	552	577	711	654
300					631	524	674	565	713	640	670	821	758
400									855	749	790	987	917
500									986	861	908	1 140	1 064
630									1 141	990	1 047	1 323	1 239

Table A.6 – Correction factors for groups of more than one circuit or of more than one multi-core cable to be used with current carrying capacities of Tables A.1 to A.5

<table>
<tr><th rowspan="2">Item</th><th rowspan="2">Arrangement
(cables touching)</th><th colspan="12">Number of circuits or multi-core cables</th><th rowspan="2">To be used with current-carrying capacities, reference</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>12</th><th>16</th><th>20</th></tr>
<tr><td>1</td><td>Bunched in air, on a surface, embedded or enclosed</td><td>1,00</td><td>0,80</td><td>0,70</td><td>0,65</td><td>0,60</td><td>0,57</td><td>0,54</td><td>0,52</td><td>0,50</td><td>0,45</td><td>0,41</td><td>0,38</td><td>Methods B,C,E and F</td></tr>
<tr><td>2</td><td>Single layer on bulkhead, deck or unperforated tray</td><td>1,00</td><td>0,85</td><td>0,79</td><td>0,75</td><td>0,73</td><td>0,72</td><td>0,72</td><td>0,71</td><td>0,70</td><td colspan="3" rowspan="4">No further reduction factor for more than nine circuits or multicore cables</td><td rowspan="2">Method C</td></tr>
<tr><td>3</td><td>Single layer fixed directly under a non metallic deckhead</td><td>0,95</td><td>0,81</td><td>0,72</td><td>0,68</td><td>0,66</td><td>0,64</td><td>0,63</td><td>0,62</td><td>0,61</td></tr>
<tr><td>4</td><td>Single layer on a perforated horizontal or vertical tray</td><td>1,00</td><td>0,88</td><td>0,82</td><td>0,77</td><td>0,75</td><td>0,73</td><td>0,73</td><td>0,72</td><td>0,72</td><td rowspan="2">Methods E and F</td></tr>
<tr><td>5</td><td>Single layer on ladder support or cleats etc.,</td><td>1,00</td><td>0,87</td><td>0,82</td><td>0,80</td><td>0,80</td><td>0,79</td><td>0,79</td><td>0,78</td><td>0,78</td></tr>
</table>

NOTE 1 These factors are applicable to uniform groups of cables, equally loaded.

NOTE 2 Where horizontal clearances between adjacent cables exceeds twice their overall diameter, no reduction factor need be applied.

NOTE 3 The same factors are applied to:

– groups of two or three single-core cables;

– multi-core cables.

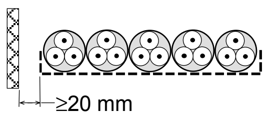
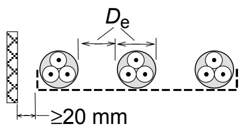
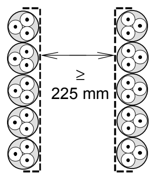
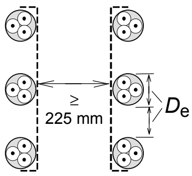
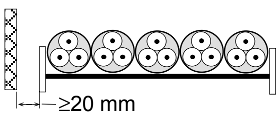
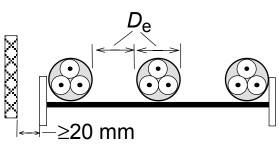
NOTE 4 If a system consists of both two- and three-core cables, the total number of cables is taken as the number of circuits, and the corresponding factor is applied to the tables for two loaded conductors for the two-core cables, and to the tables for three loaded conductors for the three-core cables.

NOTE 5 If a group consists of *n* single-core cables it may either be considered as *n*/2 circuits of two loaded conductors or *n*/3 circuits of three loaded conductors.

NOTE 6 The values given have been averaged over the range of conductor sizes and types of installation included in Tables A.1 to A.5 the overall accuracy of tabulated values is within 5 %.

NOTE 7 For some installations and for other methods not provided for in the above table, it may be appropriate to use factors calculated for specific cases, see for example tables A.7 and A.8.

Table A.7 – Correction factors for group of more than one multi-core cable to be applied to reference ratings for multi-core cables in free air – Method of installation E in Tables A.1 to A.5

Method of installation			Number of trays	Number of cables per tray or ladder					
				1	2	3	4	6	9
Perforated trays (Note 3)		Touching 	1	1,00	0,88	0,82	0,79	0,76	0,73
			2	1,00	0,87	0,80	0,77	0,73	0,68
			3	1,00	0,86	0,79	0,76	0,71	0,66
		Spaced 	1	1,00	1,00	0,98	0,95	0,91	–
			2	1,00	0,99	0,96	0,92	0,87	–
			3	1,00	0,98	0,95	0,91	0,85	–
Vertical perforated trays (Note 4)		Touching 	1	1,00	0,88	0,82	0,78	0,73	0,72
			2	1,00	0,88	0,81	0,76	0,71	0,70
		Spaced 	1	1,00	0,91	0,89	0,88	0,87	–
			2	1,00	0,91	0,88	0,87	0,85	–
Ladder supports, cleats, etc. (Note 3)		Touching 	1	1,00	0,87	0,82	0,80	0,79	0,78
			2	1,00	0,86	0,80	0,78	0,76	0,73
			3	1,00	0,85	0,79	0,76	0,73	0,70
		Spaced 	1	1,00	1,00	1,00	1,00	1,00	–
			2	1,00	0,99	0,98	0,97	0,96	–
			3	1,00	0,98	0,97	0,96	0,93	–

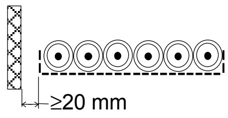
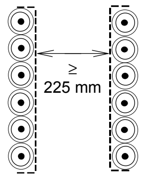
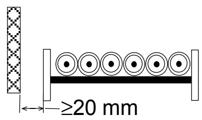
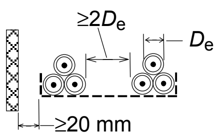
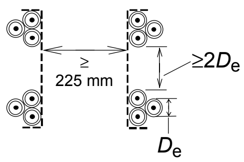
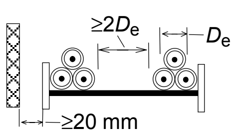
NOTE 1 Values given are averages for the cable types and range of conductor sizes considered in tables A.1 to A.5. The spread of values is generally less than 5 %.

NOTE 2 Factors apply to single layer groups of cables as shown above and do not apply when cables are installed in more than one layer touching each other. Values for such installations may be significantly lower and must be determined by an appropriate method.

NOTE 3 Values are given for vertical spacings between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing the factors should be reduced.

NOTE 4 Values are given for horizontal spacing between trays of 225 mm with trays mounted back to back. For closer spacing the factors should be reduced.

Table A.8 – Correction factors for groups of more than one circuit of single-core cables to be applied to reference rating for one circuit of single-core cables in free air – Method of installation F in Tables A.1 to A.5

Method of installation			Number of trays	Number of three-phase circuits per tray or ladder (note 5)			Use as a multiplier to rating for
				1	2	3	
Perforated trays (Note 3)		Touching  	1 2 3	0,98 0,96 0,95	0,91 0,87 0,85	0,87 0,81 0,78	Three cables in horizontal formation
Vertical perforated trays (Note 4)		Touching  	1 2	0,96 0,95	0,86 0,84	– –	Three cables in vertical formation
Ladder supports, cleats, etc. (Note 3)		Touching  	1 2 3	1,00 0,98 0,97	0,97 0,93 0,90	0,96 0,89 0,86	Three cables in horizontal formation
Perforated trays (Note 3)		 	1 2 3	1,00 0,97 0,96	0,98 0,93 0,92	0,96 0,89 0,86	Three cables in trefoil formation
Vertical perforated trays (Note 4)		Spaced  	1 2	1,00 1,00	0,91 0,90	0,89 0,86	
Ladder supports, cleats, etc. (Note 3)		 	1 2 3	1,00 0,97 0,96	1,00 0,95 0,94	1,00 0,93 0,90	

NOTE 1 Values given are averages for the cable types and range of conductor sizes considered in table A.1 to A.5. The spread of values is generally less than 5 %.

NOTE 2 Factors are given for single layers of cables (or trefoil groups) as shown in the table and do not apply when cables are installed in more than one layer touching each other. Values for such installations may be significantly lower and must be determined by an appropriate method.

NOTE 3 Values are given for vertical spacings between trays of 300 mm. For closer spacing the factors should be reduced.

NOTE 4 Values are given for horizontal spacing between trays of 225 mm with trays mounted back to back and at least 20 mm between the tray and any wall. For closer spacing the factors should be reduced.

NOTE 5 For circuits having more than one cable in parallel per phase, each three phase set of conductors should be considered as a circuit for the purpose of this table.

Annex B
(informative)

Tabulated current carrying capacities – General installations

B.1 General

These current carrying capacities are derived from those as documented in the main text of publications of IEC 60092-352 previous to 2003:

Current ratings currently available from various approval authorities for use in the general case for continuous service are shown in tables B.1 to B.5 and are recommended as being applicable to both unarmoured and armoured cables laid in free air as a group of four bunched together.

These ratings may be considered applicable, without correction factors, for cables bunched together on cable trays, in cable conduits, pipes or trunking, unless more than six cables, which may be expected to operate simultaneously at their full rated capacity, are laid close together in a cable bunch in such a way that there is an absence of free air circulation around them. In this case a correction factor of 0,85 should be applied.

NOTE Cables are said to be bunched when two or more are contained within a single conduit, trunking or duct, or if not enclosed, are not separated from each other.

These ratings have been calculated using the basis given below for an ambient temperature of 45 °C and a conductor temperature that is assumed to be equal to the maximum rated temperature of the insulation and continuously maintained. The cable constructions are based on the various insulating materials given in IEC 60092-351 together with any type of sheathing material given in IEC 60092-359.

The basis for the calculation of the ratings in Tables B.1 to B.5 is as follows.

The tables incorporated in this standard for the current ratings give only average values; these are not exactly applicable to all cable constructions and all installation conditions existing in practice. They are nevertheless recommended for general application, considering that the errors (a few degrees Celsius in the estimated operating temperature) are of little importance against the advantages of having a single international standard for the evaluation of the current ratings. In particular cases, however, a more precise evaluation shall be permitted, based on experimental or calculated data acceptable to all interested parties

The current ratings I, in amperes, have been calculated for each nominal cross-sectional area A, in square millimetres, with the formula:

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

where α is a coefficient related to the maximum permissible service temperature of the conductor as follows:

Maximum permissible temperature of the conductor		60 °C	70 °C	85 °C	90 °C	95 °C
Values of α for nominal	≥ 2,5 mm²	9,5	12	16	17	18
Cross-sectional area	<2,5 mm²	8	11,5	16	18	20

NOTE When a mineral insulated cable is installed in such a location that its copper sheath is liable to be touched by hand when in service, the current rating shown in column 6 shall be multiplied by the correction factor 0,80 in order that the sheath temperature does not exceed 70 °C.

The ambient temperature of 45 °C, on which the current ratings in Tables B.1 to B.5 are based, is considered as a standard value for the ambient air temperature, generally applicable for any kind of ship and for navigation in any climate.

When, however, ships are considered for particular uses e.g. for instance: coasters, ferries, harbour craft, and the ambient temperature is known to be permanently lower than 45 °C, it is permitted to increase the current ratings from those in the tables – but in no case shall the ambient temperature be considered to be lower than 35 °C.

When, on the other hand, it is to be expected that the air temperature around the cables could be higher than 45 °C (for instance, when a cable is wholly or partly installed in spaces or compartments where heat is produced or higher cable temperatures could be reached due to heat transfer), the current ratings from the tables B.1 to B.5 shall be reduced.

The correction factors for these different ambient air temperatures are given in table B.3.

Table B.1 – Current carrying capacities in continuous service at maximum rated conductor temperature of 60 °C

Nominal cross-sectional area mm²	Current carrying capacity					
	Single core A		2 core A		3 or 4 core A	
1,5	10		9		7	
2,5	17		14		12	
4	23		20		16	
6	29		25		20	
10	40		34		28	
16	54		46		38	
25	71		60		50	
35	88		75		62	
50	110		94		77	
70	135		115		95	
95	164		139		115	
120	189		161		132	
150	218		185		153	
185	248		211		174	
240	292		248		204	
300	336		286		235	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	390	380	332	323	273	266
500	450	430	383	366	315	301
630	520	470	442	400	364	329
Ambient air temperature 45 °C						

Table B.2 – Current carrying capacities in continuous service at maximum rated conductor temperature of 70 °C

Nominal cross-sectional area mm²	Current carrying capacity					
	Single core A		2 core A		3 or 4 core A	
1,5	15		13		11	
2,5	21		18		15	
4	29		25		20	
6	37		31		26	
10	51		43		36	
16	68		58		48	
25	90		77		63	
35	111		94		78	
50	138		117		97	
70	171		145		120	
95	207		176		145	
120	239		203		167	
150	275		234		193	
185	313		266		219	
240	369		314		258	
300	424		360		297	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	500	490	425	417	350	343
500	580	550	493	468	406	385
630	670	610	570	519	469	427
Ambient air temperature: 45 °C						

Table B.3 – Current carrying capacities in continuous service at maximum rated conductor temperature of 85 °C

<table>
<tr><th rowspan="2">Nominal cross-sectional area
mm²</th><th colspan="6">Current carrying capacity</th></tr>
<tr><th colspan="2">Single core
A</th><th colspan="2">2 core
A</th><th colspan="2">3 or 4 core
A</th></tr>
<tr><td>1,5</td><td colspan="2">21</td><td colspan="2">18</td><td colspan="2">15</td></tr>
<tr><td>2,5</td><td colspan="2">28</td><td colspan="2">24</td><td colspan="2">20</td></tr>
<tr><td>4</td><td colspan="2">38</td><td colspan="2">32</td><td colspan="2">27</td></tr>
<tr><td>6</td><td colspan="2">49</td><td colspan="2">42</td><td colspan="2">34</td></tr>
<tr><td>10</td><td colspan="2">67</td><td colspan="2">57</td><td colspan="2">47</td></tr>
<tr><td>16</td><td colspan="2">91</td><td colspan="2">77</td><td colspan="2">64</td></tr>
<tr><td>25</td><td colspan="2">120</td><td colspan="2">102</td><td colspan="2">84</td></tr>
<tr><td>35</td><td colspan="2">148</td><td colspan="2">126</td><td colspan="2">104</td></tr>
<tr><td>50</td><td colspan="2">184</td><td colspan="2">156</td><td colspan="2">129</td></tr>
<tr><td>70</td><td colspan="2">228</td><td colspan="2">194</td><td colspan="2">160</td></tr>
<tr><td>95</td><td colspan="2">276</td><td colspan="2">235</td><td colspan="2">193</td></tr>
<tr><td>120</td><td colspan="2">319</td><td colspan="2">271</td><td colspan="2">223</td></tr>
<tr><td>150</td><td colspan="2">367</td><td colspan="2">312</td><td colspan="2">257</td></tr>
<tr><td>185</td><td colspan="2">418</td><td colspan="2">355</td><td colspan="2">293</td></tr>
<tr><td>240</td><td colspan="2">492</td><td colspan="2">418</td><td colspan="2">344</td></tr>
<tr><td>300</td><td colspan="2">565</td><td colspan="2">480</td><td colspan="2">396</td></tr>
<tr><td></td><td>d.c.</td><td>a.c.</td><td>d.c.</td><td>a.c.</td><td>d.c.</td><td>a.c.</td></tr>
<tr><td>400</td><td>650</td><td>630</td><td>553</td><td>536</td><td>455</td><td>441</td></tr>
<tr><td>500</td><td>740</td><td>680</td><td>629</td><td>578</td><td>518</td><td>476</td></tr>
<tr><td>630</td><td>840</td><td>740</td><td>714</td><td>629</td><td>588</td><td>518</td></tr>
<tr><td colspan="7">Ambient air temperature 45: °C</td></tr>
</table>

Table B.4 – Current carrying capacities in continuous service at maximum rated conductor temperature of 90 °C

Nominal cross-sectional area mm²	Current carrying capacity					
	Single core A		2 core A		3 or 4 core A	
1,5	23		20		16	
2,5	40		26		21	
4	51		34		28	
6	52		44		36	
10	72		61		50	
16	96		82		67	
25	127		108		89	
35	157		133		110	
50	196		167		137	
70	242		206		169	
95	293		249		205	
120	339		288		237	
150	389		331		272	
185	444		377		311	
240	522		444		365	
300	601		511		421	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	690	670	587	570	483	469
500	780	720	663	612	546	504
630	890	780	757	663	623	546
Ambient air temperature: 45 °C						

Table B.5 – Current carrying capacities in continuous service at maximum rated conductor temperature of 95 °C

Nominal cross-sectional area mm²	Current carrying capacity					
	Single core A		2 core A		3 or 4 core A	
1, 5	26		22		18	
2,5	32		27		22	
4	43		37		30	
6	55		47		39	
10	76		65		53	
16	102		87		71	
25	135		115		95	
35	166		141		116	
50	208		177		146	
70	256		218		179	
95	310		264		217	
120	359		305		251	
150	412		350		288	
185	470		400		329	
240	553		470		387	
300	636		541		445	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	760	725	646	616	532	508
500	875	810	744	689	612	567
630	1010	900	859	765	707	630
Ambient air temperature: 45 °C						

Annex C
(informative)

Fire stops

C.1 General

For vertical cable runs in enclosed or semi-enclosed spaces, fire stops shall be arranged:

a) at least at alternate deck levels, and with a maximum distance not significantly in excess of 6 m, unless installed in totally enclosed cable trunks (e.g. cable trays);

b) at the main and emergency switchboards;

c) where cables enter into an engine control room;

d) at centralised control panels for propulsion machinery and essential auxiliaries;

e) at the entrance to cable trunks.

For horizontal cable runs in enclosed or semi-enclosed spaces, fire stops shall be as specified in Item (a) above. The maximum distance may be increased to 14 m.

The fire stops according to Items (a) and (b) above shall be

(i) for vertical cable runs in not totally enclosed trunks or open trays:

– a cable penetration installed in a steel plate of at least 3 mm thickness covering the whole cross-section of the trunk;

– alternatively, a recognised type of fire protective coating applied to the entire run length may be used;

(ii) for open vertical cable runs:

– a cable penetration installed in a steel plate as for item (i), but the plate extending all around to twice the largest dimension of the cable run but not necessarily extending through bulkheads or solid sides of trunks;

– alternatively, a recognised type of fire protective coating applied to the entire run length may be used;

(iii) for open horizontal cable runs:

– a cable penetration installed in a steel plate as for item (i), but the plate extending all around to twice the largest dimension of the cable run though not necessarily extending through ceilings, decks, bulkheads or solid sides of trunks;

– alternatively, a recognised type of fire protective coating, applied to at least 1 m length of the cable run.

NOTE 1 Test procedure for such fire protective coating is under consideration.

NOTE 2 When cables are protected by fire protective coatings, the possible effect on the cable service temperature shall be considered.

In cargo holds and underdeck passageways in the cargo area, fire stops need be fitted only at the boundaries of the compartment.

In all cases the SOLAS requirements shall also be observed.

Annex D
(informative)

Cable splicing

D.1 Procedure

Cable splicing should consist of a conductor connector, replacement insulation, replacement cable sheath, and, where applicable, replacement armour and shielding. Cable splices should establish electrical continuity in conductors, armour, or screens. Splicing should be performed as follows.

Conductors should be joined using a compression type butt connector. A one-cycle compression tool and proper dies should be used. A long barrel butt connector with conductor stops should be used for conductor sizes 6 mm^2 or larger.

Splices in multiconductor cables should be staggered in such a way that the connector for each conductor is not contiguous to the connector of an adjacent conductor. The conductor insulation should be removed no more than necessary to accept the connector.

Conductor replacement insulation that has the same or a greater thickness than that of the cable insulation, and the same or better thermal and electrical properties of the cable, should be applied.

For screened cables, replacement screening should be provided. Replacement elements should be secured by a method that does not exert more pressure than necessary to establish adequate electrical contact. Screened cables should have at least a 13-mm overlap between replacement shielding material and the permanent screening.

The replacement cable sheath material should have physical properties that are the same as, or equivalent to, the cable sheath. The replacement cable sheath should be centered over the splice and should overlap the existing cable sheath by at least 51 mm. The replacement cable sheath should be installed to make a watertight seal with the existing cable sheath.

Electrical continuity of any cable armour should be re-established. A jumper of wire or braid, or replacement armour of the same metal, should be installed.

For cable with a sheath over the armour, a replacement covering should be applied.

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