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Mobile and fixed offshore units – Electrical installations –

Part 4: Cables

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS –

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FOREWORD

International Standard IEC 61892-4 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units, in cooperation with SC 18A: Cables and cable installations.

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

FDIS	Report on voting
18/1052/FDIS	18/1058/RVD

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

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

A list of all parts of the IEC 61892 series, published under the general title *Mobile and fixed offshore units – Electrical installations,* can be found on the IEC website.

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

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- withdrawn;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

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

INTRODUCTION

IEC 61892 forms a series of International Standards intended to enable safety in the design, selection, installation, maintenance and use of electrical equipment for the generation, storage, distribution and utilisation of electrical energy for all purposes in offshore units which are being used for the purpose of exploration or production of petroleum resources.

This part of IEC 61892 also incorporates and coordinates, as far as possible, existing rules and forms a code of interpretation, where applicable, of the requirements of the International Maritime Organisation. It also constitutes a guide for future regulations which may be prepared and a statement of practice for offshore unit owners, constructors and appropriate organisations.

This standard is based on equipment and practices which are in current use but it is not intended in any way to impede development of new or improved techniques.

The ultimate aim has been to produce a set of International standards exclusively for the offshore petroleum industry.

MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS –

Part 4: Cables

1 Scope

This part of IEC 61892 specifies requirements for the choice and installation of electrical cables intended for fixed electrical systems in mobile and fixed offshore units, including pumping or “pigging” stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, production, processing and for storage purposes.

The reference to fixed electrical systems includes those that are subjected to vibration due to the movement of the unit, e.g. cables installed on a drag chain, and not those that are intended for repeated flexing. Cables suitable for repeated flexing use are detailed in other IEC specifications, e.g. IEC 60227 and IEC 60245, and their uses on board offshore units are restricted to those situations which do not directly involve exposure to a marine environment, e.g. portable tools, domestic appliances, etc.

The following types and applications of cables are not included:

- optical fibre cables;
- sub-sea and umbilical cables;
- cables supplying downhole pumps;
- data, telecommunication and radio frequency cables.

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 60038:1983, *IEC standard voltages*[1)]
Amendment 1 (1994)
Amendment 2 (1997)

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

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

1) There exists a consolidated edition 6.2 (2002) including IEC 60038:1983 and its Amendments 1 and 2.

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

IEC 60754-2:1991, *Test on gases evolved during combustion of electric cables – Part 2: 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 – Part 2: Test procedure and requirements*

IEC 61892-1:2001, *Mobile and fixed offshore units – Electrical installations – Part 1: General requirements and conditions*

IEC 61892-2, *Mobile and fixed offshore units – Electrical installations – Part 2: System design*

IEC 61892-6, *Mobile and fixed offshore units – Electrical installations – Part 6: Installation*

3 Terms and definitions

3.1
appropriate authority
governmental body and/or classification society with whose rules an offshore unit is required to comply

3.2
braid armour
covering formed from braided metal wires used to protect the cable from external mechanical effects

3.3
braid
covering made of plaited metallic or non-metallic material

3.4
core insulated conductor
assembly comprising a conductor and its own insulation (and screens, if any)

3.5
core screen
electric screen of non-metallic and/or metallic materials covering the insulation

3.6
insulated cable
an assembly consisting of:
– one or more cores,
– their individual covering(s) (if any)
– assembly protection (if any)
– protective coverings (if any)

NOTE Additional uninsulated conductor(s) may be included in the cable.

3.7
conductor screen
non-metallic conducting layer applied between the conductor and insulation to equalise the electrical stress between these components. It may also provide smooth surfaces as the boundaries of the insulation and assist in the elimination of spaces at these boundaries

3.8
inner sheath
inner jacket (North America) non-metallic extruded sheath applied under a metallic sheath, reinforcement, or armour

NOTE

It must be extruded.

It can be used to fill the interstices.

It must be a material listed in IEC 60092-359.

It has a defined nominal thickness (value).

3.9
outer sheath
jacket (North America)

non-metallic extruded sheath applied over a metallic sheath, reinforcement, or armour It must be extruded.

NOTE 1

It can be used to fill the interstices.

It must be a material listed in IEC 60092-359.

It has a defined nominal thickness (value).

NOTE 2 The term sheath is only used for metallic coverings in North America, where the term jacket is used for non-metallic coverings.

3.10
electrostatic screen
electrostatic shield (North America)
surrounding earthed metallic layer to confine the electric field within the cable cores, pair(s), triples(s), or quad(s), and to protect the pair(s), triad(s), or quad(s) from external influence

4 Types, installation and operating conditions of cables

4.1 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 mobile and fixed offshore units.

4.2 Voltage rating

4.2.1 Power frequency cables

The maximum rated voltage (U) considered in this standard for power frequency cables is 30 kV.

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

– U_0 is the rated power frequency 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 highest 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 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 should not exceed 125 h.

- **Category C**

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

The nominal system voltages from 3,3 kV to 30 kV shown in Table 1 are generally in accordance with Series 1 in IEC 60038. For nominal system voltages intermediate between these standard voltages and also between 0,6/1 kV and 1,8/3,3 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 17,5 kV system, the cable is to have a rated voltage not less than 12/20 kV.

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

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

System voltage		**System category**	**Minimum rated voltage of cable U_0/U**	
Nominal voltage U kV	**Maximum sustained voltage, U_m** kV		**Unscreened** kV	**Single-core or screened** kV
up to 0,25	0,30	A, B or C	0,15 / 0,25	–
1	1,2	A, B or C	0,6 / 1,0	0,6 /1,0
3	3,6	A or B	1,8 / 3,0	1,8 / 3,0
3	3,6	C		3,6 / 6,0
6	7,2	A or B		3,6 / 6,0
6	7,2	C		6,0 / 10
10	12	A or B		6,0 / 10
10	12	C		8,7 / 15
15	17,5	A or B		8,7 / 15
15	17,5	C		12 /20
20	24	A or B		12 / 20
20	24	C		18 / 30
30	36	A or B		18 / 30

4.2.2 Control and instrumentation cables

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

In some instances for conductor sizes 1 mm^2 and larger, or when circuits are to be supplied from a low impedance source, 0,6/1 kV rated cables shall be used as control or instrumentation cables.

4.3 Cross-sectional areas of conductors and current-carrying capacities

4.3.1 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:

a) The highest load to be carried by the cable shall be calculated from the load demands and diversity factors given in IEC 61892-2.

b) 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 4.3.4, 4.3.5 and 4.3.6.

c) The voltage drop in the circuit shall not exceed the limits specified by the appropriate authority for the circuits concerned - further guidance is given in 4.4.

d) The cross-sectional area of the conductor shall be able to accommodate the mechanical and thermal effects of a short circuit current (see 4.8) and the effect upon voltage drop of motor-starting currents (see 4.4, Note 3).

e) The nominal cross-section 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 area determined by each of the methods.

NOTE 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 is permitted, based on experimental or calculated data acceptable to all interested parties

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

Arrangement of earth conductor		Cross-section Q of associated current-carrying conductor (One phase or pole) mm^2	Minimum cross-section of earth conductor
1	i) Insulated earth conductor in cable for fixed installation.	$Q \leq 16$	Q
	ii) Copper braid of cable for fixed installation according to subclause 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.	$Q > 16$	50% of the current-carrying conductor, but not less than 16 mm^2
2	Uninsulated earth conductor in cable for fixed installation, being laid under the cable's armour or copper braid and in metal-to-metal contact with this.	$Q \leq 2{,}5$	1 mm^2
		$2{,}5 < Q \leq 6$	1,5 mm^2
		$Q > 6$	Not permitted
3	Separately installed earth conductor for fixed installation other than specified in 1 iii) and 1 iv).	$Q < 2{,}5$	Same as current-carrying conductor subject to min. 1,5 mm^2 for stranded earthing connection or 2,5 mm^2 for unstranded earthing connection
		$2{,}5 < Q \leq 120$	50 % of current-carrying conductor, but not less than 4 mm^2
		$Q > 120$	70 mm^2
4	Insulated earth conductor in flexible cable.	$Q \leq 16$	Same as current-carrying conductor
		$Q > 16$	50 % of current-carrying conductor, but minimum 16 mm^2
NOTE Refer also to 4.3.1 for method based on rating of fuses.			
[a] The term protective conductor is accepted as an alternative term for the earth continuity conductor.			

4.3.2 Current-carrying capacities

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

4.3.3 Current-carrying capacities for continuous service

Continuous service for a cable shall be considered, for the purpose of this standard, as a current-carrying service with constant load having a duration longer than three times the thermal time constant of the cable, i.e., longer than the critical duration (see Figure 1).

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.

These current-carrying capacities are derived from those as documented in IEC 60092-352:1997.

Current ratings currently available from various approval authorities for use in the general case for continuous service are shown in Tables 4 through 6 and are recommended as being applicable to both unarmoured and armoured cables laid in free air as a group of six 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 60092-351 together with any type of sheathing material given in 60092-359.

The basis for the calculation of the ratings in Tables 4 to 6 is as follows:

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:

Table 3 – Coefficient related to maximum permissible temperature of the conductor

Maximum permissible temperature of the conductor		**70 °C**	**90 °C**	**95 °C**
Values of α for nominal cross-sectional area	≥ 2,5 mm²	12	17	18
	<2,5 mm²	11,5	18	20

For two-, three- and four-conductor cables, the current ratings given in Table 3 should be multiplied by the following (approximate) correction factors:

0,85 for two core cables,

0,70 for three- and four-core cables.

The ambient temperature of 45 °C, on which the current ratings in Tables 4 through 6 are based, is considered as a standard value for the ambient air temperature, generally applicable for any kind of offshore unit in any climate.

When, however, fixed offshore units are installed in locations where 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 25 °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 4 through 6 shall be reduced.

The correction factors for these different ambient air temperatures are given in Table 7 or 8.

The selection of the method applicable to any particular installation is the responsibility of the appropriate approval authority or governing regulation. An optional alternative method is given in Appendix A (Informative) when utilized under Engineering Supervision.

Table 4 – Current-carrying capacities in continuous service at maximum rated conductor temperature of 70 °C (ambient air temperature 45 °C)

Rated conductor temperature	70 °C		
Nominal cross-sectional area (mm²)	Single-core (A)	2-core (A)	3- or 4-core (A)
1	12	10	8
1,5	15	13	10
2,5	20	18	15
4	29	24	20
6	37	31	26
10	51	43	35
16	68	58	48
25	90	76	63
35	111	94	78
50	138	118	97
70	171	145	120
95	207	176	145
120	239	203	167
150	275	234	192
185	313	266	219
240	369	313	258
300	424	360	297
400	508	431	355
500	583	496	408
630	674	573	472

Table 5 – Current-carrying capacities in continuous service at maximum rated conductor temperature of 90 °C (ambient air temperature 45 °C)

Conductor temperature	90 °C		
Nominal cross-sectional area	**Single-core**	**2-core**	**3- or 4-core**
(mm²)	**(A)**	**(A)**	**(A)**
1	18	15	13
1,5	23	20	16
2,5	30	26	21
4	40	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	273
185	444	377	311
240	522	444	366
300	601	511	420
400	719	611	503
500	827	703	579
630	955	812	669

Table 6 – Current-carrying capacities in continuous service at maximum rated conductor temperature of 95 °C (ambient air temperature 45 °C)

Conductor temperature	95 °C		
Nominal cross-sectional area (mm²)	Single-core (A)	2-core (A)	3- or 4-core (A)
1	20	17	14
1,5	26	22	18
2,5	32	27	22
4	43	36	30
6	55	47	39
10	76	65	53
16	102	87	71
25	135	114	94
35	166	141	116
50	208	176	145
70	256	218	179
95	310	263	217
120	359	305	251
150	412	351	289
185	470	400	329
240	553	470	387
300	636	541	445
400	761	647	533
500	875	744	613
630	1011	860	708

4.3.4 Correction factors for different ambient air temperatures

The ambient temperature is the temperature of the surrounding medium when the cable(s) or insulated conductor(s) under consideration are not loaded.

The current-carrying capacity tabulated in this subclause and in Annex A assumes the following reference ambient temperatures for insulated conductors and cables in air, irrespective of the method of installation:

- 45 °C for standard situations, generally applicable for any kind of unit and in any climate;
- 30 °C for particular situations, applicable for mobile and fixed offshore units for particular uses for which the ambient temperature is known to be permanently lower or equal to 30 °C.

Where the ambient temperature in the intended location of the insulated conductors or cables differs from the reference ambient temperature, the appropriate correction factors specified in Table 7 and Table 8 shall be applied to the values of current-carrying capacity set out in this subclause and in Annex A.

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.

Table 7 – Correction factor for various ambient air temperatures (reference ambient temperature of 45 °C)

Maximum conductor temperature	Correction factors for ambient air temperatures												
°C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	75 °C	80 °C	85 °C
70	1,32	1,25	1,18	1,10	1,00	0,89	0,77	0,63	-	-	-	-	-
90	1,20	1,15	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	-
95	1,18	1,14	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 8 – Correction factor for various ambient air temperatures (reference ambient temperature of 30 °C)

Maximum conductor temperature	Correction factors for ambient air temperatures													
°C	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	75 °C	80 °C	85 °C
70	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	-	-	-	-	-
90	1,08	1,04	1,00	0,96	0,91	0,87	0,82	0,76	0,71	0,65	0,58	0,50	0,41	-
95	1,07	1,04	1,00	0,96	0,92	0,88	0,83	0,78	0,73	0,68	0,62	0,55	0,48	0.39

4.3.5 Correction factors for short time duty

If a cable is intended to supply a motor or equipment operating for periods of half an hour or one hour, its current rating, as given by the relevant table (see 4.3.3 and Annex A), may be increased using the relevant correction factors given by Figure 2. These correction factors are applicable only if the intermediate periods of rests are longer than the critical duration (which is equal to three times the time constant of the cable), given in Figure 1 as a function of the cable diameter.

NOTE 1 The correction factors given in Figure 2 are approximate and depend mainly upon the diameter of the cable. In general, the half-an-hour service is applicable to mooring winches. The half-an-hour rating might not be adequate for automatic tensioning mooring winches.

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

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

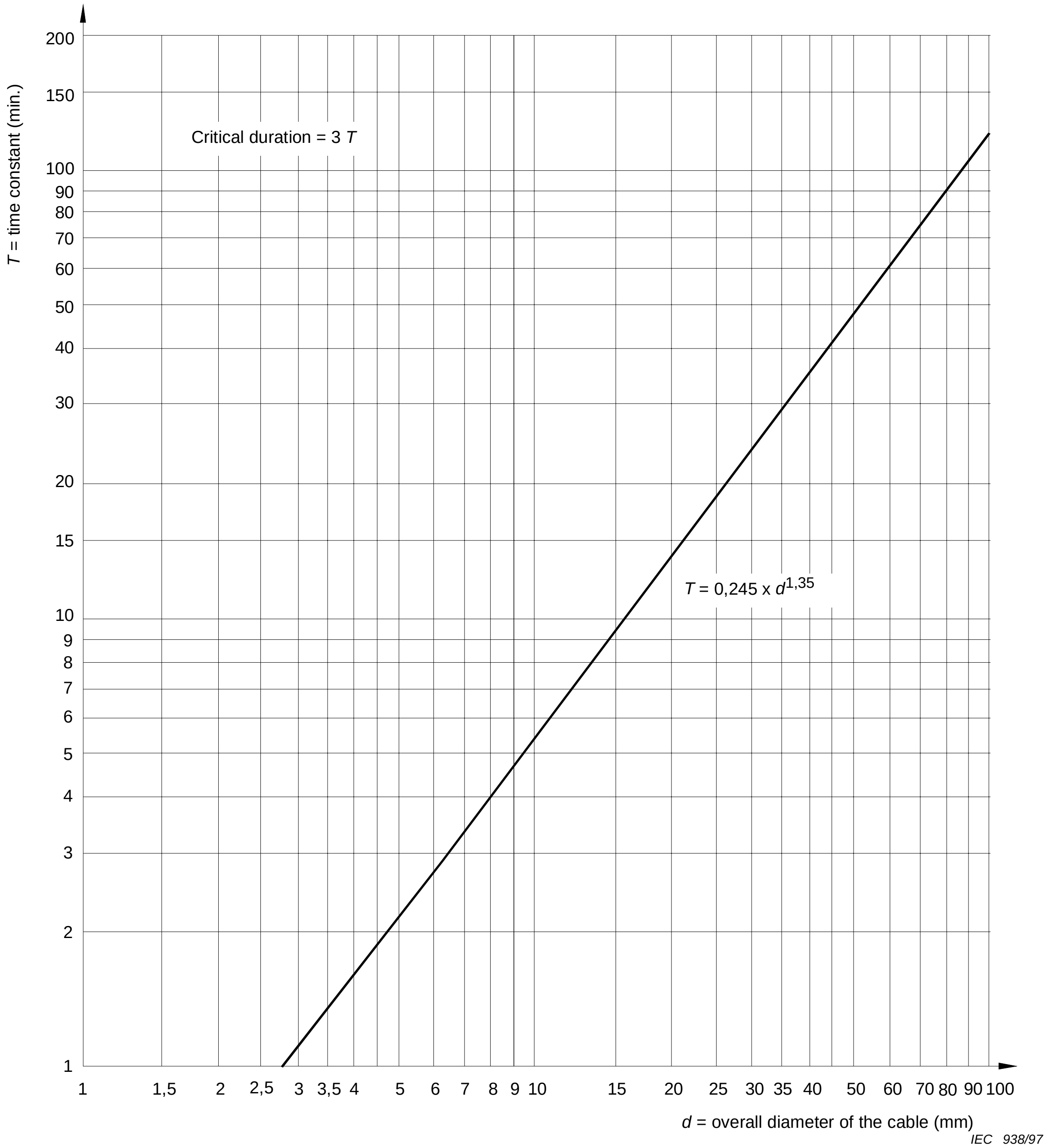
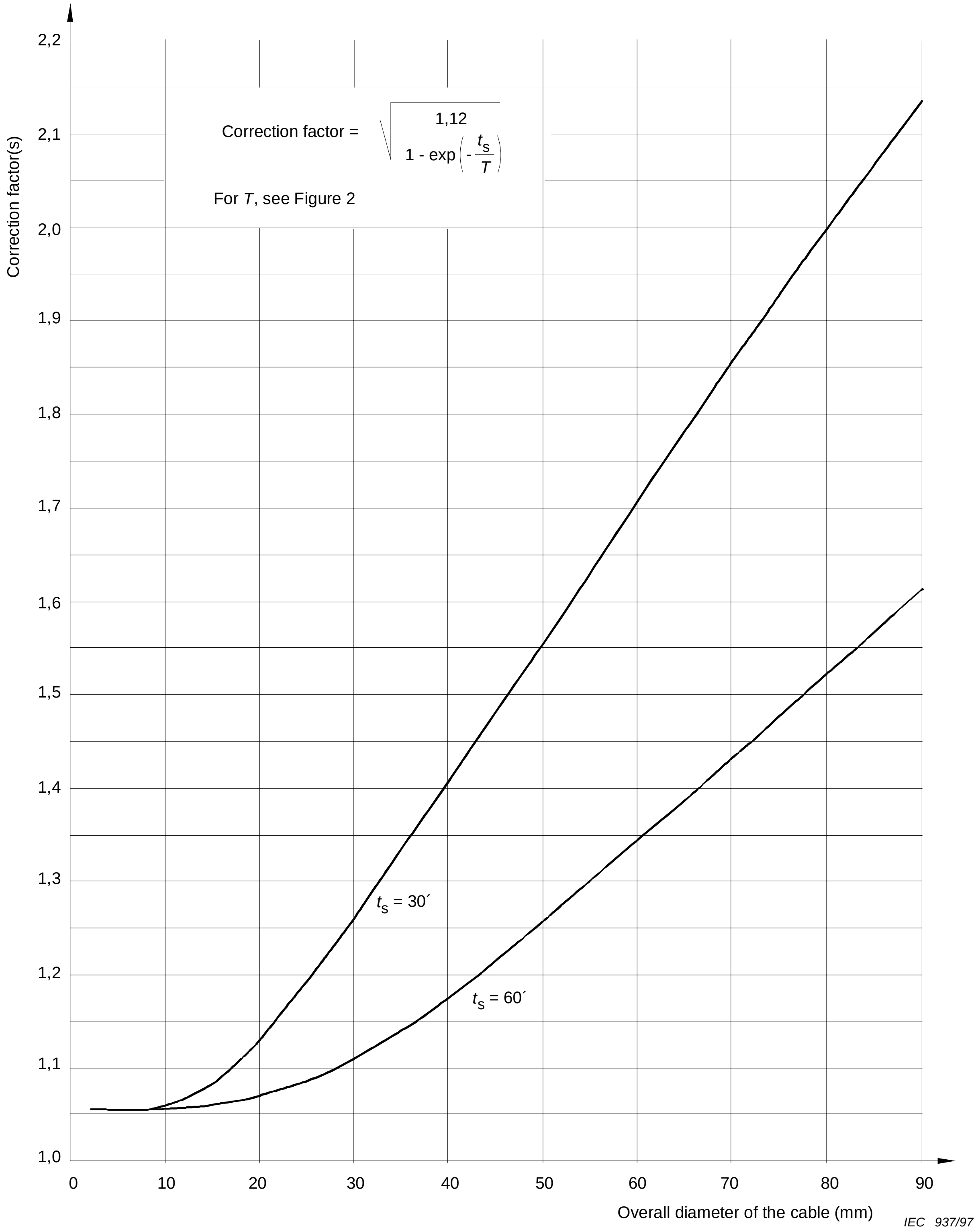
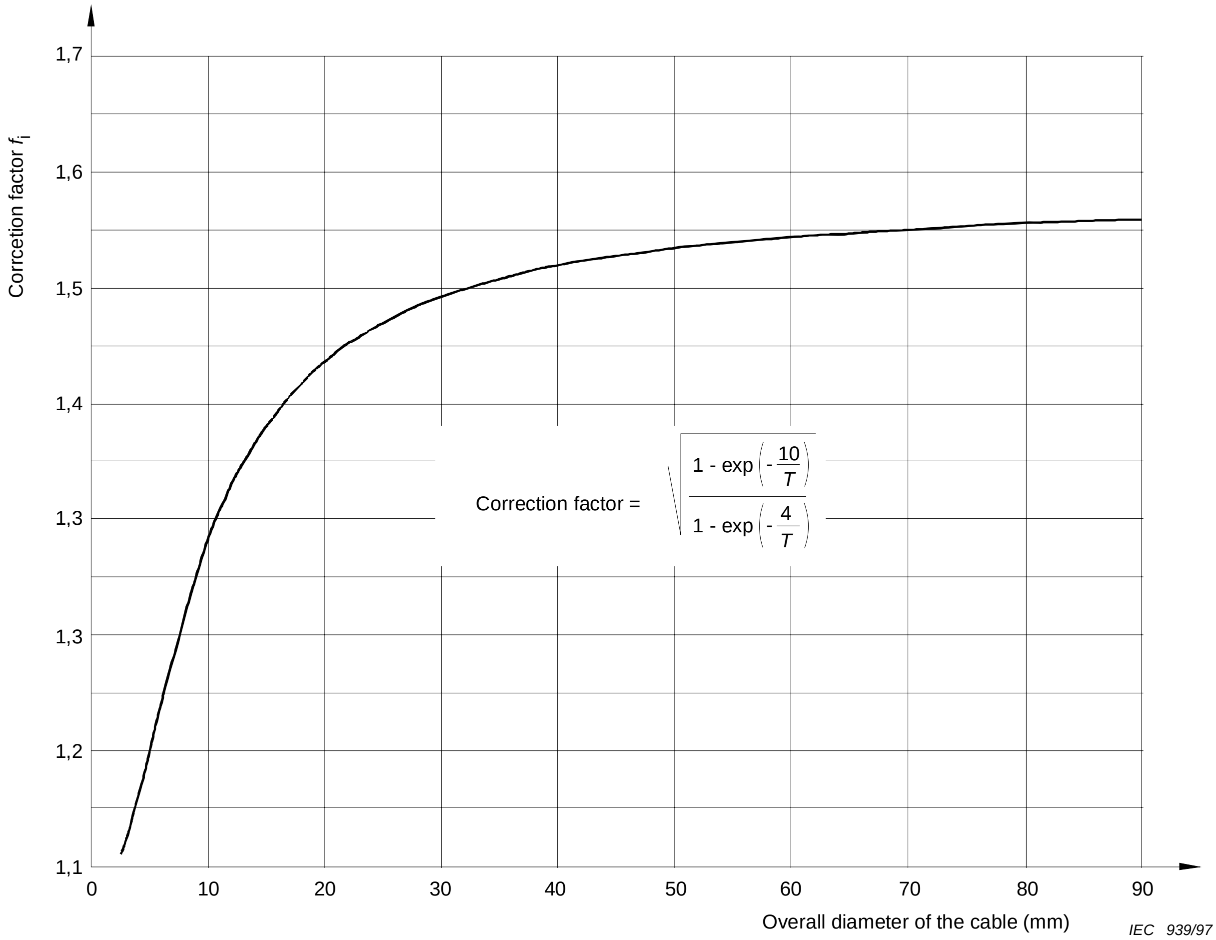


Figure 1 – Time constant of cables



t_S = service time

Figure 2 – Correction factors for half-hour and one-hour service



Intermittence period = 10 min Intermittence ratio = 40 %

Figure 3 – Correction factor for intermittent service

4.3.6 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 4.3.3 or the tables of Annex A.

The group reduction 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 the lowest maximum operating temperature of any cable in the group together with the appropriate group reduction 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.

4.4 Voltage drop

In the absence of specific design limits or limits set by the appropriate authority the cross-sectional areas of conductors shall be so determined that the drop in voltage from the main or emergency switchboard bus-bars to any and every point on the installation when the conductors are carrying the maximum current under normal conditions of service, does not exceed the limitation given in 4.9 of IEC 61892-1.

NOTE 1 For supplies from batteries with a voltage not exceeding 50 V, this value may be increased to 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 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 voltage drops or dips.

4.5 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 as to take only 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.

4.6 Parallel connection of cables

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

4.7 Separation of circuits

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

a) 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.

b) Non-essential circuits with voltages not exceeding the “safety voltage” as defined in IEC 61892-1. Also consideration shall be given to fire performance characteristics and electromagnetic interference, see 4.14 and IEC 61892-6 respectively.

4.8 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.

4.9 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. Class 5 conductors are also recommended for use to ease the installation of cables in areas involving tight bending radii or high vibration, or which are subject to occasional flexing.

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

4.10 Insulation material

The range of materials for use as conductor insulation shall be as listed in IEC 60092-351. The rated operating temperature of the insulating material 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.

4.11 Screen, core screen or shield

The construction of the screen, core screen or shield shall be as specified in the relevant part identified in 4.1.

4.12 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 water condensation, harmful vapours (including oil vapour), oil or drilling fluids may be present. In this instance the cables shall meet the appropriate fluid resistance requirements of IEC 60092-359.

NOTE 1 Not all materials in IEC 60092-359 meet the fluid resistance requirement.

NOTE 2 Guidance for cables required to be resistant to drilling fluids (“mud”) is given in Annex D.

NOTE 3 In hazardous locations, inner taped coverings used in lieu of an inner sheath will not prevent the migration of combustible gas or dust particles through the cable. This is normally prevented by hazardous location rated cable glands dependent upon an impervious inner sheath on which to affect a seal.

In choosing different types of over sheathing as a protective coverings, due 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 oversheath is considered insufficient, the cable shall be fitted in pipes or conduits or trunking or be otherwise protected.

All thermoset sheathed cables shall be suitable for an oil production installation. The oil resistance properties shall be demonstrated by a test according to IEC 60092-359, Table II, Clause 3, type SHF2.

Also consideration shall be given to the fire performance characteristics given in 4.14.

4.13 Metallic braid armour

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

NOTE In case of single-core cables, or cables for circuits with high contents of harmonic, as e.g. SCR circuits non-magnetic braid or armour is normally to be used.

4.14 Fire performance

All cables or insulated wiring shall meet the requirements for flame spread as given in IEC 60332-1-2 and 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 mobile and fixed offshore units. 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 B.

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.

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

NOTE 5 Guidance for testing of cables required to withstand a hydrocarbon fire is given in Annex C.

Cables for installation in accommodation spaces and passenger areas shall be of low smoke / zero halogen construction.

Where applicable, the cables shall be evaluated in accordance with the following test methods given in:

- IEC 61034-2
- IEC 60754-1
- IEC 60754-2

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

4.15 Bending radius

The internal bending radius for the installation of cables shall be as recommended by the manufacturer according to the type of cables chosen, and shall not be less than values given in Table 9 and Table 10.

Table 9 – 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*
[a] 6 *D* for defined circuit integrity			

Table 10 – 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
NOTE For cables rated at 3,6/6(7,2) kV and above employing flexible conductor stranding (Class 5) and braid insulation shields indicating a minimum bend radius of 6D for unarmoured cables and 8D for armoured cables in concurrence with the approval of the cable manufacturer		

Annex A
(informative)
Tabulated current-carrying capacities – Defined installations

A.1 General

The current ratings in Tables A.1 to A.8 are applicable for d.c. and a.c. with a nominal frequency of 50 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.8 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.8 are based on the nominal dimensions of 600/1000 V cables. Current ratings for higher voltage cables, up to 30 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.8 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 offshore units the following reference methods of IEC 60364-5-52 are considered applicable and are presented in Tables A.1 to A.8 (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 B1** (insulated conductors in a conduit on a bulkhead) and **B2** (multi-core cable in a conduit on a bulkhead).

  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).

  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).

  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

- Cable on or under a deck: this is similar to reference **method C** except that the rating for a cable under a deck is slightly reduced (see Table A.11) from the value for a bulkhead or on a deck because of the reduction in natural convection.
- 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**.
- 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**.
- 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**.
- 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.8 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

For installation methods B and C the current-carrying capacities given in Tables A.1 to A.8 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.9 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.

For installations methods E and F on trays, cleats and the like, 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 Table A.10 and Table A.11 – see the following notes.

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.

NOTE 4 Group correction factors have been calculated on the basis that the group consists of similar equally loaded insulated conductors or cables. When a group contains various sizes of cable or insulated conductor, caution should be exercised over the current loading of the smaller ones.

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

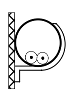
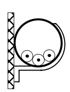
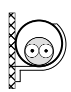
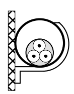
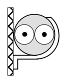
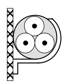
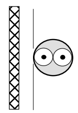
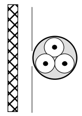
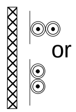
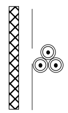
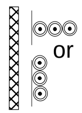
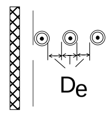
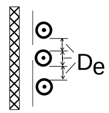
Nominal cross-sectional area of conductor	Installation method												
	Method B1 Insulated conductors or single-core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**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	10,5	9,5	10	9	12	10,5	13,5	11,5					
2,5	14,5	13	14	12	16,5	14,5	18,5	15,5					
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**

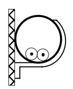
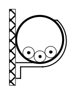
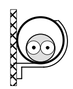
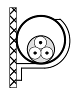
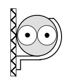
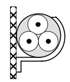
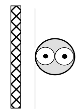
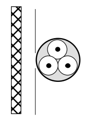
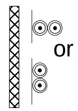
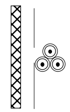
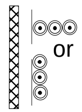
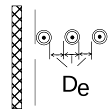
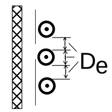
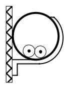
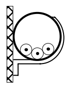
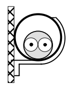
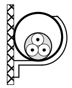
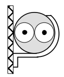
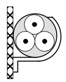
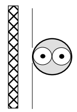
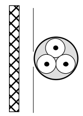
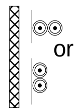
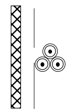
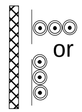
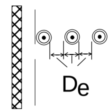
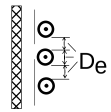
Nominal cross-sectional area of conductor	Installation method												
	Method B1 Insulated conductors or single-core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**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													
1,5	14	12	13	12	15,5	14	17,5	14,5					
2,5	19	16,5	18	16	21	19	24	20					
4	25	22	24	21	28	25	32	27					
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 conductor temperature 85 °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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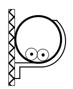
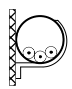
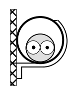
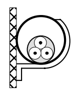
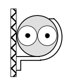
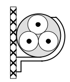
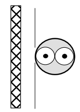
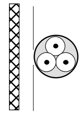
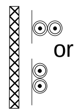
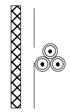
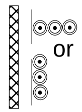
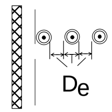
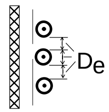
2,5	25	23	25	21	27	25	30	26					
4	34	30	33	29	37	33	40	34					
6	44	39	42	36	48	43	52	44					
10	62	54	57	49	66	58	71	62					
16	82	72	75	66	88	79	94	82					
25	109	96	98	86	113	98	122	104	132	111	116	149	132
35	134	118	120	105	140	121	152	130	164	139	144	185	165
50	162	144	144	126	171	147	185	157	198	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	1027	959
630									1 028	892	944	1 192	1 117

**Table A.4 – Current-carrying capacities in amperes –
Copper conductor temperature 60 °C and reference ambient air temperature 30 °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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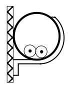
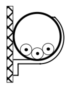
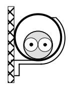
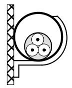
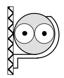
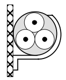
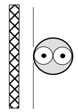
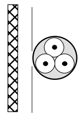
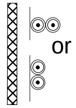
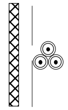
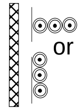
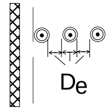
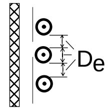
2,5	21	18,5	20	17,5	23,5	21	26	22					
4	28	24	26	23	31	28	35	30					
6	36	31	33	30	40	36	44	37					
10	50	44	45	40	55	50	61	52					
16	66	59	60	54	74	66	82	70					
25	88	77	78	70	97	84	104	88	114	96	99	127	113
35	109	96	97	86	120	104	129	110	141	119	124	157	141
50	131	117	116	103	146	125	157	133	171	145	151	191	171
70	167	149	146	130	185	160	202	171	218	188	196	244	221
95	202	180	175	156	224	194	245	207	264	230	239	297	271
120	234	208	202	179	260	225	285	240	306	268	279	345	315
150					299	260	330	278	353	310	324	397	365
185					341	297	378	317	403	356	371	453	418
240					401	351	447	374	475	422	441	535	495
300					461	404	516	432	547	488	511	617	573
400									656	571	599	741	692
500									755	652	686	854	800
630									874	744	787	990	931

**Table A.5 – Current-carrying capacities in amperes –
Copper conductors temperature 70 °C and reference ambient temperature 30 °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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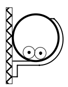
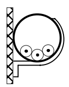
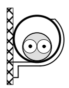
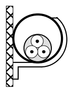
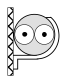
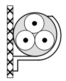
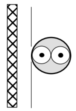
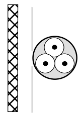
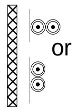
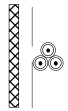
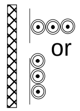
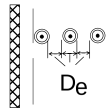
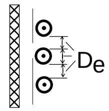
2,5	24	21	23	20	27	24	30	25					
4	32	28	30	27	36	32	40	34					
6	41	36	38	34	46	41	51	43					
10	57	50	52	46	63	57	70	60					
16	76	68	69	62	85	76	94	80					
25	101	89	90	80	112	96	119	101	131	110	114	146	130
35	125	110	111	99	138	119	148	126	162	137	143	181	162
50	151	134	133	118	168	144	180	153	196	167	174	219	197
70	192	171	168	149	213	184	232	196	251	216	225	281	254
95	232	207	201	179	258	223	282	238	304	264	275	341	311
120	269	239	232	206	299	259	328	276	352	308	321	396	362
150					344	299	379	319	406	356	372	456	419
185					392	341	434	364	463	409	427	521	480
240					461	403	514	430	546	485	507	615	569
300					530	464	593	497	629	561	587	709	659
400									754	656	689	852	795
500									868	749	789	982	920
630									1 005	855	905	1 138	1 070

**Table A.6 – Current-carrying capacities in amperes –
Copper conductors temperature 85 °C and reference ambient temperature 30 °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	30	27	29	25	32	29	35	31					
4	40	36	38	34	43	38	47	40					
6	52	46	49	42	56	50	60	52					
10	72	63	66	58	77	68	83	72					
16	96	84	87	77	103	92	110	96					
25	128	112	114	101	132	114	143	122	155	130	135	175	155
35	157	138	140	123	164	141	178	152	192	162	169	217	193
50	190	168	168	148	201	172	216	184	232	199	207	264	236
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95	294	258	254	224	315	267	338	286	362	315	328	413	373
120	340	300	293	257	367	309	394	332	420	368	384	480	436
150					423	356	454	383	484	426	445	554	506
185					486	407	520	438	552	490	512	635	581
240					575	480	615	516	652	583	609	750	690
300					665	553	711	596	752	675	707	866	800
400									902	790	833	1042	968
500									1040	908	958	1203	1122
630									1204	1 044	1 105	1 396	1 308

Table A.7 – Current-carrying capacities in amperes – Copper conductors temperature 90 °C and reference ambient temperature 45 °C

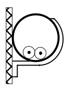
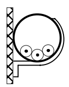
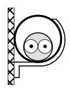
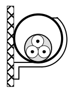
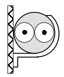
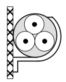
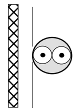
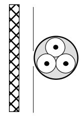
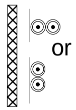
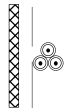
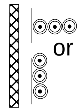
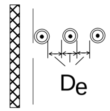
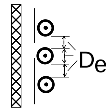
Nominal cross-sectional area of conductor	Installation method												
	Method B1 Insulated conductors or single-core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**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	20	17,5	19	17	21	19	23	20					
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	371	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.8 – Current-carrying capacities in amperes –
Copper conductors temperature 95 °C and reference ambient temperature 45 °C**

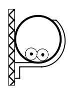
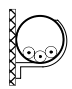
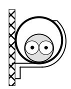
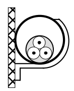
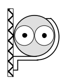
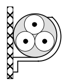
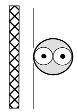
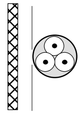
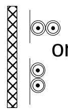
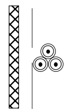
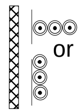
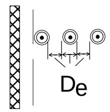
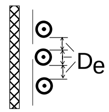
Nominal cross-sectional area of conductor	Installation method												
	Method B1 Insulated conductors or single-core cables in conduit on a bulkhead		**Method B2** Multi-core cable in conduit on a bulkhead		**Method C** Multi-core cables on a bulkhead		**Method E** Multi-core cables in free air		**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.9 – 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.8

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

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

NOTE 2 Where horizontal clearance 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 and
- multi-core cables.

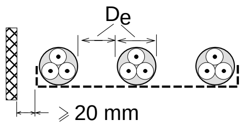
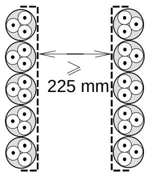
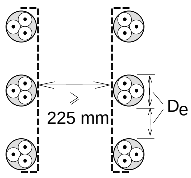
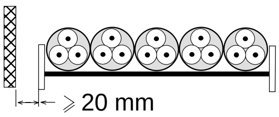
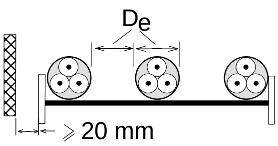
NOTE 4 If a system consists of both two- and three-core cables, the total number of cables is taken as the number of circuits, and the corresponding factor is applied to the tables for two loaded conductors for the two-core cables, and to the tables for three loaded conductors for the three-core cables.

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.8, 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.10 and A.11.

Table A.10 – 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.8

Method of installation			Number of trays	Number of cables					
				1	2	3	4	5	6
Perforated trays [a]		Touching 	1 2 3	1,00 1,00 1,00	0,88 0,87 0,86	0,82 0,80 0,79	0,79 0,77 0,76	0,76 0,73 0,71	0,73 0,68 0,66
		Spaced 	1 2 3	1,00 1,00 1,00	1,00 0,99 0,98	0,98 0,96 0,95	0,95 0,92 0,91	0,91 0,87 0,85	– – –
Vertical perforated trays [b]		Touching 	1 2	1,00 1,00	0,88 0,88	0,82 0,81	0,78 0,76	0,73 0,71	0,72 0,70
		Spaced 	1 2	1,00 1,00	0,91 0,91	0,89 0,88	0,88 0,87	0,87 0,85	– –
Ladder supports, cleats, etc. [a]		Touching 	1 2 3	1,00 1,00 1,00	0,87 0,86 0,85	0,82 0,80 0,79	0,80 0,78 0,76	0,79 0,76 0,73	0,78 0,73 0,70
		Spaced 	1 2 3	1,00 1,00 1,00	1,00 0,99 0,98	1,00 0,98 0,97	1,00 0,97 0,96	1,00 0,96 0,93	– – –

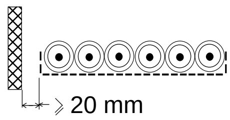
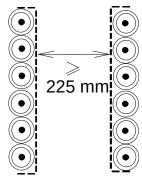
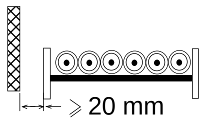
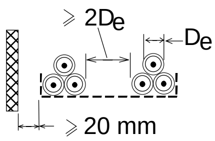
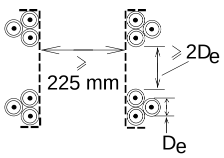
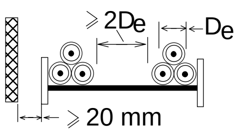
NOTE 1 Values given are averages for the cable types and range of conductor sizes considered in Tables A.1 to A.8. The spread of values is generally less than 5 %.

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.

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

[b] 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.11 – 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.8

Method of installation			Number of trays	Number of three-phase circuits per tray or ladder [c]			Use as a multiplier to rating for
				1	2	3	
Perforated trays [a]		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 [b]		Touching 	1 2	0,96 0,95	0,86 0,84	– –	Three cables in vertical formation
Ladder supports, cleats, etc.[a]		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 [a]			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 [b]		Spaced 	1 2	1,00 1,00	0,91 0,90	0,89 0,86	
Ladder supports, cleats, etc.[a]			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.8. 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.

[a] Values are given for vertical spacing between trays of 300 mm. For closer spacing the factors should be reduced.

[b] 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.

[c] 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)

Fire stops

B.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 under deck 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 C
(Informative)

Jet fire test for hydrocarbon (HCF) fire resistant cables

C.1 General

The fire curve for hydrocarbon (HCF) fire resistant cables shall be according to Fig.C.1.

C.1.1 HC fire curves

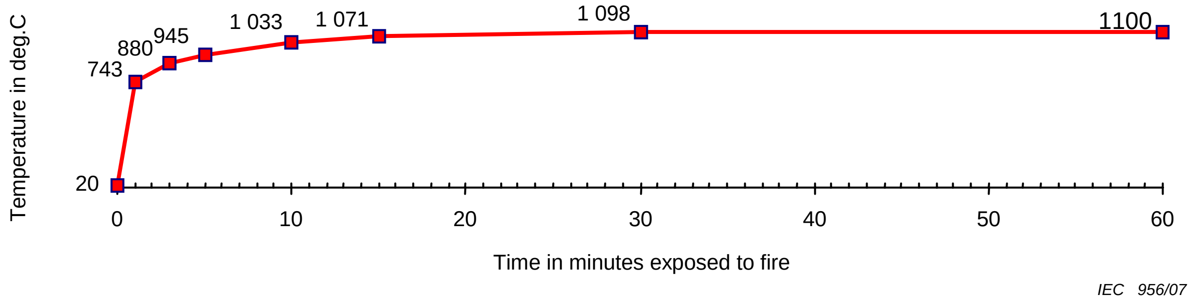


Figure C.1 – International recognized HC fire curve

C.1.2 Tests-requirements

There shall be no breakdown for 30 min or 60 min when connected to operating voltage. Time to breakdown shall be agreed upon with the customer or appropriate authority.

C.2 Tests methods for jet fire test for hydrocarbon (HCF) fire resistant cables

The purpose of this test is to expose cables for high temperatures, and to simulate fires in oil or gas like they may occur offshore, on board offshore units and in refineries.

C.2.1 Test equipment

The oven shall consist of a mineral fibre insulated combustion chamber with the dimensions of 450 mm × 450 mm × 900 mm. The chamber volume shall be approximately 180 l.

The oven shall be fired with propane.

Ten burners shall be placed in two rows (five in each row) in the bottom of the combustion chamber.

The total rating of the burners shall be 300 000 BTU (88 kW) which can give temperatures up to 1 400 ºC.

The burners shall have programmable controllers to set and measure temperature and time.

C.2.2 Procedure

The cable specimen shall be placed horizontally in the oven and the part of cable that is exposed to the fire shall be approximately 900 mm. The cable specimen shall be positioned in the middle of the combustion chamber and shall be approximately 300 mm over the burners.

Annex D
(Informative)

Drilling fluid test procedure and requirements

D.1 Drilling fluid resistance test

Drilling fluids are used in almost every oilfield drilling operation. The fluids used in the so-called drilling fluid systems may come into contact with cables and may affect the functioning of cables. The suitability of electric cable sheathing materials (as given in IEC 60092-359) for exposure to these drilling fluids is heavily dependent on the type of drilling fluid present. To be called drilling fluid-resistant / mud-resistant, the cable sheathing material shall pass the test requirements below for 3 of the 5 mentioned drilling fluids/muds.

D.2 Oil to be used

The various drilling fluids can be grouped in 5 categories and for each category specific test drilling fluids are defined:

	Drilling fluid type	Test fluid	Temperature	Duration
1	Water based mud	Calcium Bromide Brine	70 °C	56 d
2	Oil based mud	Carbo Sea	70 °C	56 d
3	Ester based mud	Accolade Base	70 °C	56 d
4	Mineral oil type	IRM 903	100 °C	7 d
5	Mineral oil type	IRM 902	100 °C	7 d

In order to qualify a particular material in one or more of these categories the material shall be tested separately for each category in the representative test drilling fluids.

D.3 Procedure

The tests pieces shall be immersed in mud/oil batch previously heated to be at 70 °C / 100 °C and shall be maintained in mud/oil at that temperature for 56 days / 7 days. At the end of the specific duration, the test pieces shall be removed from the mud/oil, blotted lightly to remove excess oil excess and suspended in air at ambient temperature for at least for 16 h but not more than 24 h,unless otherwise specified in the relevant cable standard. At this end of this period, any further excess mud/oil shall be removed by lightly blotting the tests pieces.

D.4 Requirements (drilling fluids/mud types)

a) Tensile strength: maximum variations from unaged samples of 40 %
b) Elongation at break: maximum variations from unaged samples of 40 %
c) Volume swell at break: maximum variation from unaged samples of 20 %
d) Change in weight: maximum variation from unaged samples of 15 %

D.5 Requirements mineral oil

a) Tensile strength: maximum variations from unaged samples of 30 %
b) Elongation at break: maximum variations from unaged samples of 30 %
c) Volume swell at break: maximum variation from unaged samples of 30 %
d) Change in weight: maximum variation from unaged samples of 30 %

D.6 Expression of results

The calculation of tensile strength shall be based on the area of the test piece before immersion. The difference between the median value obtained of the five tests pieces immersed in oil and the median value of the values obtained for the unaged tests pieces expressed as a percentage of the latter, shall not exceed the percentage specified in the requirements above in D.4 and D.5 a) and b).

NOTE Materials meeting this drilling fluid resistance qualification test are not automatically approved for use in a specific drilling fluid or in particular operating conditions, specific agreement with the cable manufacturer and/or additional testing in the specific oil and particular conditions is needed.

Bibliography

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SOLAS, *International Convention for the Safety of Life at Sea*

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[2]) The second edition of IEC 60092-352 (1997) has been superseded by a third edition, IEC 60092-352:2005, *Choice and installation of electrical cables.* However for the purposes of this document, the second edition applies.

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