INTERNATIONAL STANDARD

IEC 60502-2

Edition 1.1
1998-11

Edition 1:1997 consolidated with amendment 1:1998

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

Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)

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*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES FROM 1 kV (U_m = 1,2 kV) UP TO 30 kV (U_m = 36 kV) –

Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
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International Standard IEC 60502-2 has been prepared by subcommittee 20A: High-voltage cables, of IEC technical committee 20: Electric cables.

This consolidated version of IEC 60502-2 is based on the first edition (1997) [documents 20A/319/FDIS and 20A/348/RVD] and its amendment 1 (1998) [documents 20A/383/FDIS and 20A/385/RVD].

It bears the edition number 1.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

IEC 60502 consists of the following parts, under the general title: Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV):

– Part 1: Cables for rated voltages of 1 kV (U_m = 1,2 kV) and 3 kV (U_m = 3,6 kV);
– Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV);
– Part 3: Reserved;
– Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV).

Annexes A, B, C, D and E form an integral part of this standard.

The contents of the corrigendum of February 1999 have been included in this copy.

POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES FROM 1 kV (U_m = 1,2 kV) UP TO 30 kV (U_m = 36 kV) –

Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)

1 Scope

This part of IEC 60502 specifies the construction, dimensions and test requirements of power cables with extruded solid insulation from 6 kV up to 30 kV for fixed installations such as distribution networks or industrial installations.

Cables for special installation and service conditions are not included, for example cables for overhead networks, the mining industry, nuclear power plants (in and around the containment area), submarine use or shipboard application.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60502. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60502 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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IEC 60038:1983, *IEC standard voltages*

IEC 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60502-2:1997
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IEC 60183:1984, *Guide to the selection of high-voltage cables*

IEC 60228:1978, *Conductors of insulated cables*

IEC 60230:1966, *Impulse tests on cables and their accessories*

IEC 60332-1:1993, *Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable*

IEC 60502-1:1997, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 1: Cables for rated voltages of 1 kV (U_m = 1,2 kV) and 3 kV (U_m = 3,6 kV)*

IEC 60811-1-1:1993, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*

IEC 60811-1-2:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 2: Thermal ageing methods*

IEC 60811-1-3:1993, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 3: Methods for determining the density – Water absorption tests – Shrinkage test*

IEC 60811-1-4:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 4: Tests at low temperature*

IEC 60811-2-1:1986, *Common test methods for insulating and sheathing materials of electric cables – Part 2: Methods specific to elastomeric compounds – Section 1: Ozone resistance test – Hot set test – Mineral oil immersion test*

IEC 60811-3-1:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section 1: Pressure test at high temperature – Tests for resistance to cracking*

IEC 60811-3-2:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section 2: Loss of mass test – Thermal stability test*

IEC 60811-4-1:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 4: Methods specific to polyethylene and polypropylene compounds – Section 1: Resistance to environmental stress cracking – Wrapping test after thermal ageing in air – Measurement of the melt flow index – Carbon black and/or mineral content measurement in PE*

IEC 60885-2:1987, *Electrical test methods for electric cables – Part 2: Partial discharge tests*

IEC 60885-3:1988, *Electrical test methods for electric cables – Part 3: Test methods for partial discharge measurements on lengths of extruded power cables*

IEC 60986:1989, *Guide to the short-circuit temperature limits of electric cables with a rated voltage from 1,8/3 (3,6) kV to 18/30 (36) kV*

ISO 48:1994, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

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3 Definitions

For the purpose of this part of IEC 60502, the following definitions apply.

3.1 Definitions of dimensional values (thicknesses, cross-sections, etc.)

3.1.1
nominal value
value by which a quantity is designated and which is often used in tables. Usually, in this standard, nominal values give rise to values to be checked by measurements taking into account specified tolerances.

3.1.2
approximate value
value which is neither guaranteed nor checked; it is used, for example, for the calculation of other dimensional values

3.1.3
median value
when several test results have been obtained and ordered in an increasing (or decreasing) succession, the median value is the middle value if the number of available values is odd, and the mean of the two middle values if the number is even

3.1.4
fictitious value
value calculated according to the "fictitious method" described in annex A

3.2 Definitions concerning the tests

3.2.1
routine tests
tests made by the manufacturer on each manufactured length of cable to check that each length meets the specified requirements

3.2.2
sample tests
tests made by the manufacturer on samples of completed cable or components taken from a completed cable, at a specified frequency, so as to verify that the finished product meets the specified requirements

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3.2.3
type tests
tests made before supplying, on a general commercial basis, a type of cable covered by this standard, in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated, unless changes are made in the cable materials or design or manufacturing process which might change the performance characteristics.

3.2.4
electrical tests after installation
tests made to demonstrate the integrity of the cable and its accessories as installed

4 Voltage designations and materials

4.1 Rated voltages

The rated voltages $U_0/U(U_m)$ of the cables considered in this standard are as follows:

$$U_0/U(U_m) = 3{,}6/6\ (7{,}2) – 6/10\ (12) – 8{,}7/15\ (17{,}5) – 12/20\ (24) – 18/30\ (36)\ \text{kV}.$$

NOTE 1 – The voltages given above are the correct designations although in some countries other designations are used e.g. 3,5/6 – 5,8/10 – 11,5/20 – 17,3/30 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" for which the equipment may be used (see IEC 60038).

The rated voltage of the cable for a given application shall be suitable for the operating conditions in the system in which the cable is used. To facilitate the selection of the cable, systems are divided into 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 disconnected from the system within 1 min;

– category B: this category comprises those systems which, under fault conditions, are operated for a short time with one phase earthed. This period, according to IEC 60183, should not exceed 1 h. For cables covered by this standard, a longer period, not exceeding 8 h on any occasion, can be tolerated. The total duration of earth faults in any year should not exceed 125 h;

– category C: this category comprises all systems which do not fall into category A or B.

NOTE 2 – It should be realized that in a system where an earth fault is not automatically and promptly isolated, the extra stresses on the insulation of cables during the earth fault reduce the life of the cables to a certain degree. If the system is expected to be operated fairly often with a permanent earth fault, it may be advisable to classify the system in category C.

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The values of U_0 recommended for cables to be used in three-phase systems are listed in table 1.

Table 1 – Recommended rated voltages U_0

Highest system voltage (U_m) kV	Rated voltage (U_0) kV	
	Categories A and B	**Categorie C**
7,2	3,6	6,0
12,0	6,0	8,7
17,5	8,7	12,0
24,0	12,0	18,0
36,0	18,0	–

4.2 Insulating compounds

The types of insulating compound covered by this standard are listed in table 2, together with their abbreviated designations.

Table 2 – Insulating compounds

Insulating compound	Abbreviated designation
a) *Thermoplastic*	
polyvinyl chloride intended for cables with rated voltages U_0/U = 3,6/6 kV	PVC/B*
b) *Thermosetting:*	
ethylene propylene rubber or similar (EPM or EPDM)	EPR
high modulus or hard grade ethylene propylene rubber	HEPR
cross-linked polyethylene	XLPE

* Insulating compound based on polyvinyl chloride intended for cables with rated voltages $U_0/U \le$ 1,8/3 kV is designated PVC/A in IEC 60502-1.

The maximum conductor temperatures for different types of insulating compound covered by this standard are given in table 3.

Table 3 – Maximum conductor temperatures for different types of insulating compound

Insulating compound		Maximum conductor temperature °C	
		Normal operation	Short-circuit (5 s maximum duration)
Polyvinyl chloride	(PVC/B)		
	Conductor cross-section ≤300 mm²	70	160
	Conductor cross-section >300 mm²	70	140
Cross-linked polyethylene	(XLPE)	90	250
Ethylene propylene rubber	(EPR and HEPR)	90	250

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The temperatures in table 3 are based on the intrinsic properties of the insulating materials. It is important to take into account other factors when using these values for the calculation of current ratings.

For example, in normal operation, if a cable directly buried in the ground is operated under continuous load (100 % load factor) at the maximum conductor temperature shown in the table, the thermal resistivity of the soil surrounding the cable may, in the course of time, increase from its original value as a result of drying-out processes. As a consequence, the conductor temperature may greatly exceed the maximum value. If such operating conditions are foreseen, adequate provisions shall be made.

For guidance on the short-circuit temperatures, reference should be made to IEC 60986.

4.3 Sheathing compounds

The maximum conductor temperatures for the different types of sheathing compound covered by this standard are given in table 4.

Table 4 – Maximum conductor temperatures for different types of sheathing compound

Sheathing compound	Abbreviated designation	Maximum conductor temperature in normal operation °C
a) *Thermoplastic:*		
polyvinyl chloride (PVC)	ST_1	80
	ST_2	90
polyethylene	ST_3	80
	ST_7	90
b) *Elastomeric:*		
polychloroprene, chlorosulfonated polyethylene or similar polymers	SE_1	85

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5 Conductors

The conductors shall be either of class 1 or class 2 of plain or metal-coated annealed copper or of plain aluminium or aluminium alloy in accordance with IEC 60228. For class 2 conductors measures may be taken to achieve longitudinal watertightness.

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6 Insulation

6.1 Material

Insulation shall be extruded dielectric of one of the types listed in table 2.

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6.2 Insulation thickness

The nominal insulation thicknesses are specified in tables 5 to 7.

The thickness of any separator or semi-conducting screen on the conductor or over the insulation shall not be included in the thickness of the insulation.

Table 5 – Nominal thickness of PVC/B insulation

Nominal cross-sectional area of conductor mm²	Nominal thickness of insulation at rated voltage U_0/U (U_m) 3,6/6 (7,2) kV mm
10 to 1 000	3,4

NOTE – Any smaller conductor cross-section than those given in this table is not recommended. However, if a smaller cross-section is needed, either the diameter of the conductor shall be increased by a conductor screen (see 7.1), or the insulation thickness shall be increased in order to limit, at the values calculated with the smallest conductor size given in this table, the maximum electrical stresses applied to the insulation under test voltage.

Table 6 – Nominal thickness of cross-linked polyethylene (XLPE) insulation

Nominal cross-sectional area of conductor mm²	Nominal thickness of insulation at rated voltage U_0/U (U_m)				
	3,6/6 (7,2) kV mm	**6/10 (12) kV** mm	**8,7/15 (17,5) kV** mm	**12/20 (24) kV** mm	**18/30 (36) kV** mm
10	2,5	–	–	–	–
16	2,5	3,4	–	–	–
25	2,5	3,4	4,5	–	–
35	2,5	3,4	4,5	5,5	–
50 to 185	2,5	3,4	4,5	5,5	8,0
240	2,6	3,4	4,5	5,5	8,0
300	2,8	3,4	4,5	5,5	8,0
400	3,0	3,4	4,5	5,5	8,0
500 to 1 000	3,2	3,4	4,5	5,5	8,0

NOTE – Any smaller conductor cross-section than those given in this table is not recommended. However, if a smaller cross-section is needed, either the diameter of the conductor shall be increased by a conductor screen (see 7.1), or the insulation thickness shall be increased in order to limit, at the values calculated with the smallest conductor size given in this table, the maximum electrical stresses applied to the insulation under test voltage.

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Table 7 – Nominal thickness of ethylene propylene rubber (EPR) and hard ethylene propylene rubber (HEPR) insulation

Nominal cross-sectional area of conductor mm²	Nominal thickness of insulation at rated voltage U_0/U (U_m)					
	3,6/6 (7,2) kV		**6/10 (12) kV**	**8,7/15 (17,5) kV**	**12/20 (24) kV**	**18/30 (36) kV**
	Unscreened mm	**Screened** mm	mm	mm	mm	mm
10	3,0	2,5	–	–	–	–
16	3,0	2,5	3,4	–	–	–
25	3,0	2,5	3,4	4,5	–	–
35	3,0	2,5	3,4	4,5	5,5	–
50 to 185	3,0	2,5	3,4	4,5	5,5	8,0
240	3,0	2,6	3,4	4,5	5,5	8,0
300	3,0	2,8	3,4	4,5	5,5	8,0
400	3,0	3,0	3,4	4,5	5,5	8,0
500 to 1 000	3,2	3,2	3,4	4,5	5,5	8,0

NOTE – Any smaller conductor cross-section than those given in this table is not recommended. However, if a smaller cross-section is needed, either the diameter of the conductor shall be increased by a conductor screen (see 7.1), or the insulation thickness shall be increased in order to limit, at the values calculated with the smallest conductor size given in this table, the maximum electrical stresses applied to the insulation under test voltage.

7 Screening

All cables shall have a metallic layer surrounding the cores either individually or collectively.

Screening of individual cores in single or three-core cables, when required, shall consist of a conductor screen and an insulation screen. These shall be employed in all cables with the following exceptions:

a) at rated voltage 3,6/6 (7,2) kV cables insulated with EPR and HEPR may be unscreened provided the larger insulation thickness in table 7 is used;

b) at rated voltage 3,6/6 (7,2) kV cables insulated with PVC shall be unscreened.

7.1 Conductor screen

The conductor screen shall be non-metallic and shall consist of an extruded semi-conducting compound, which may be applied on top of a semi-conducting tape. The extruded semi-conducting compound shall be firmly bonded to the insulation.

7.2 Insulation screen

The insulation screen shall consist of a non-metallic semi-conducting layer in combination with a metallic layer.

The non-metallic layer shall be extruded directly upon the insulation of each core and consist of either a bonded or strippable semi-conducting compound.

A layer of semi-conducting tape or compound may then be applied over the individual cores or the core assembly.

The metallic layer shall be applied over either the individual cores or the core assembly collectively and shall comply with the requirements of clause 10.

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8 Assembly of three-core cables, inner coverings and fillers

The assembly of three-core cables depends on the rated voltage and whether a metallic screen is applied to each core.

The following subclauses 8.1 to 8.3 do not apply to assemblies of sheathed single-core cables.

8.1 Inner coverings and fillers

8.1.1 Construction

The inner coverings may be extruded or lapped.

For cables with circular cores a lapped inner covering shall be permitted only if the interstices between the cores are substantially filled.

A suitable binder is permitted before application of an extruded inner covering.

8.1.2 Material

The materials used for inner coverings and fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material.

8.1.3 Thickness of extruded inner covering

The approximate thickness of extruded inner coverings shall be derived from table 8.

Table 8 – Thickness of extruded inner covering

Fictitious diameter over laid-up cores		Thickness of extruded inner covering (approximate values) mm
Above mm	Up to and including mm	
–	25	1,0
25	35	1,2
35	45	1,4
45	60	1,6
60	80	1,8
80	–	2,0

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8.1.4 Thickness of lapped inner covering

The approximate thickness of lapped inner coverings shall be 0,4 mm for fictitious diameters over laid-up cores up to and including 40 mm and 0,6 mm for larger diameters.

8.2 Cables having a collective metallic layer (see clause 9)

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Cables shall have an inner covering over the laid-up cores. The inner covering and fillers shall comply with 8.1 and shall be non-hygroscopic except if the cable is claimed to be longitudinally watertight.

For cables having a semi-conducting screen over each individual core and a collective metallic layer, the inner covering shall be semi-conducting; the fillers may be semi-conducting.

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8.3 Cables having a metallic layer over each individual core (see clause 10)

The metallic layers of the individual cores shall be in contact with each other.

Cables with an additional collective metallic layer (see clause 9) of the same material as the underlying individual metallic layers shall have an inner covering over the laid-up cores. The inner covering and fillers shall comply with 8.1 and shall be non-hygroscopic except if the cable is claimed to be longitudinally watertight. The inner covering and fillers may be semi-conducting.

When the underlying individual metallic layers and the collective metallic layer are of different materials, they shall be separated by an extruded sheath of one of the materials specified in 14.2. For lead sheathed cables the separation from the underlying individual metallic layers may be obtained by an inner covering according to 8.1.