IEC 60502-1

Edition 3.0 2021-02

INTERNATIONAL STANDARD

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)

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IEC 60502-1:2021-02(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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)

FOREWORD

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IEC 60502-1 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This third edition cancels and replaces the second edition published in 2004 and Amendment 1:2009. This edition constitutes a technical revision.

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

a) references to IEC 60811 (all parts) have been updated and mechanical testing requirements specific to halogen free low-smoke oversheath of material type ST_8 have been considered;
b) the use of the types of sheathing material to be used is now clearly defined;
c) the applicability of cables for use in DC systems is now included in the scope;

d) items which were earlier marked as "under consideration" were studied either for an appropriate solution if found available, or for removal for the time being.

The text of this International Standard is based on the following documents:

Draft	Report on voting
20/1938/FDIS	20/1949/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60502 series, published 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)* can be found on the IEC website.

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

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

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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)

1 Scope

This part of IEC 60502 specifies the construction, dimensions and test requirements of power cables with extruded solid insulation for rated AC voltages of 1 kV (U_m = 1,2 kV) and 3 kV (U_m = 3,6 kV) for fixed installations such as distribution networks or industrial installations.

Cables of rated AC voltage 1 kV (U_m = 1,2 kV) designed and tested in accordance with this document can also be used, if declared by the manufacturer, in DC distribution systems having their nominal voltage ≤ 750 V DC (with a maximum of 900 V DC) between a live conductor and neutral/earth, or ≤ 1 500 V DC (with a maximum 1 800 V DC) between two live conductors. Applicable core identification for DC systems are considered in accordance with local installation regulations.

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NOTE 1 Recommendations for preferred core colours for line conductors in DC systems are given in IEC 60445. However, local installation regulations for DC systems can already contain specific identification requirements.

This document includes cables which exhibit properties of reduced flame spread, low levels of smoke emission and halogen-free gas emission when exposed to fire.

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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, or cables directly connected to photovoltaic systems.

NOTE 2 Cables for photovoltaic systems are covered by IEC 62930.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60183, *Guidance for the selection of high-voltage A.C. cable systems*

IEC 60228, *Conductors of insulated cables*

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

IEC 60332-1-2, *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 60332-3-24, *Tests on electric and optical cables under fire conditions – Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C*

IEC 60684-2, *Flexible insulating sleeving – Part 2: Methods of test*

IEC 60724, *Short-circuit temperature limits of electric cables with rated voltages of 1 kV (U_m = 1,2 kV) and 3 kV (U_m = 3,6 kV)*

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

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

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IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

IEC 60811-402, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 402: Miscellaneous tests – Water absorption tests*

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IEC 60811-403, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds*

IEC 60811-404, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

IEC 60811-409, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 409: Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-502, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 502: Mechanical tests – Shrinkage test for insulations*

IEC 60811-503, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 503: Mechanical tests – Shrinkage test for sheaths*

IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulations and sheaths*

IEC 60811-505, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Elongation at low temperature for insulations and sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-507, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 507: Mechanical tests – Hot set test for cross-linked materials*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 60811-605, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 605: Physical tests – Measurement of carbon black and/or mineral filler in polyethylene compounds*

IEC 60811-606, *Electric and optical fibre cables –Test methods for non-metallic materials – Part 606: Physical tests – Methods for determining the density*

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

IEC 62230, *Electric cables – Spark-test method*

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ISO 48-2:2018, *Rubber, vulcanized or thermoplastic – Determination of hardness – Part 2: Hardness between 10 IRHD and 100 IRHD*

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3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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

Note 1 to entry: Usually, in this document, 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 but 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, middle value if the number of available values is odd, and mean of the two middle values if the number is even

3.1.4
fictitious value
value calculated in accordance with the "fictitious method" described in Annex A

3.2 Definitions relating to tests

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

3.2.2
sample test
test 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

3.2.3
type test
test made before supplying, on a general commercial basis, a type of cable covered by this document, in order to demonstrate satisfactory performance characteristics to meet the intended application

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Note 1 to entry: Type 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 test after installation
test made to demonstrate the integrity of the cable and its accessories as installed

4 Voltage designations and materials

4.1 Rated voltages

4.1.1 Rated AC voltages

The rated AC voltages U_0/U (U_m) of the cables considered in this document are 0,6/1 (1,2) kV and 1,8/3 (3,6) kV.

NOTE 1 The voltages given above are the correct designations although in some countries other designations are used, e.g. 1,7/3 kV or 1,9/3,3 kV instead of 1,8/3 kV.

For the voltage designation of cables U_0/U (U_m), the definitions in IEC 60183 apply i.e.:

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

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

U_m is the maximum RMS power frequency voltage between conductors for which the cable is designed.

NOTE 2 U_m is the highest voltage that can be sustained under normal operating conditions at any time and at any point in a system and excludes temporary voltage variations due to fault conditions and sudden disconnection of large loads.

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 according to the duration of time the system can be operated under earth fault conditions (see IEC 60183):

– 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, in accordance with IEC 60183, should, in general, not exceed 1 h. For cables covered by this document, 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 3 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 can 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 AC voltages U_0

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Highest system voltage (U_m) kV	Rated voltage (U_0) kV	
	Categories A and B	Category C
1,2	0,6	0,6
3,6	1,8	3,6 [a]

[a] This category is covered by 3,6/6 (7,2) kV cables in accordance with IEC 60502-2.

4.1.2 Rated DC voltages

Under consideration.

4.2 Insulating compounds

The types of insulating compound covered by this document 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 ≤ 1,8/3 kV	PVC/A [a]
b) *Cross-linked:*	
Ethylene propylene rubber or similar (EPM or EPDM)	EPR
High modulus or hard grade ethylene propylene rubber	HEPR
Cross-linked polyethylene	XLPE
[a] Insulating compound based on polyvinyl chloride intended for cables with rated AC voltages U_0/U = 3,6/6 kV is designated PVC/B in IEC 60502-2.	

The maximum conductor temperatures for different types of insulating compound covered by this document 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/A)		
	Conductor cross-section ≤ 300 mm^2	70	160
	Conductor cross-section > 300 mm^2	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 Table 3, 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 shall be made to IEC 60724.

4.3 Sheathing compounds

The types of sheathing compound covered by this document are listed in Table 4, together with their abbreviated designations.

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

Table 4 – Sheathing compounds and 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
Halogen free	ST_8	90
b) *Elastomeric:*		
Polychloroprene, chlorosulfonated polyethylene or similar polymers	SE_1	85

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, or of Class 5 of plain or metal-coated copper in accordance with IEC 60228.

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6 Insulation

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6.1 Material

The insulation shall be extruded dielectric of one of the types listed in Table 2.

For halogen free cables, the insulation shall also meet the requirements given in Table 23.

6.2 Insulation thickness

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

The thickness of any separator shall not be included in the thickness of the insulation.

Table 5 – Nominal thickness of PVC/A insulation

Nominal cross-sectional area of conductor	Nominal thickness of insulation at rated voltage U_0/U (U_m)	
	0,6/1 (1,2) kV	1,8/3 (3,6) kV
mm²	mm	mm
1,5 and 2,5	0,8	–
4 and 6	1,0	–
10 and 16	1,0	2,2
25 and 35	1,2	2,2
50 and 70	1,4	2,2
95 and 120	1,6	2,2
150	1,8	2,2
185	2,0	2,2
240	2,2	2,2
300	2,4	2,4
400	2,6	2,6
500 to 800	2,8	2,8
1 000	3,0	3,0

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

Nominal cross-sectional area of conductor	Nominal thickness of insulation at rated voltage U_0/U (U_m)	
	0,6/1 (1,2) kV	1,8/3 (3,6) kV
mm²	mm	mm
1,5 and 2,5	0,7	–
4 and 6	0,7	–
10 and 16	0,7	2,0
25 and 35	0,9	2,0
50	1,0	2,0
70 and 95	1,1	2,0
120	1,2	2,0
150	1,4	2,0
185	1,6	2,0
240	1,7	2,0
300	1,8	2,0
400	2,0	2,0
500	2,2	2,2
630	2,4	2,4
800	2,6	2,6
1 000	2,8	2,8

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