

# INTERNATIONAL STANDARD

# IEC 60502-2

Second edition  
2005-03

---

---

**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)**

*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.*



Reference number  
IEC 60502-2:2005(E)

# INTERNATIONAL STANDARD

# IEC 60502-2

Second edition  
2005-03

---

---

**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)**

© IEC 2005 Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

PRICE CODE **XC**

*For price, see current catalogue*

## CONTENTS

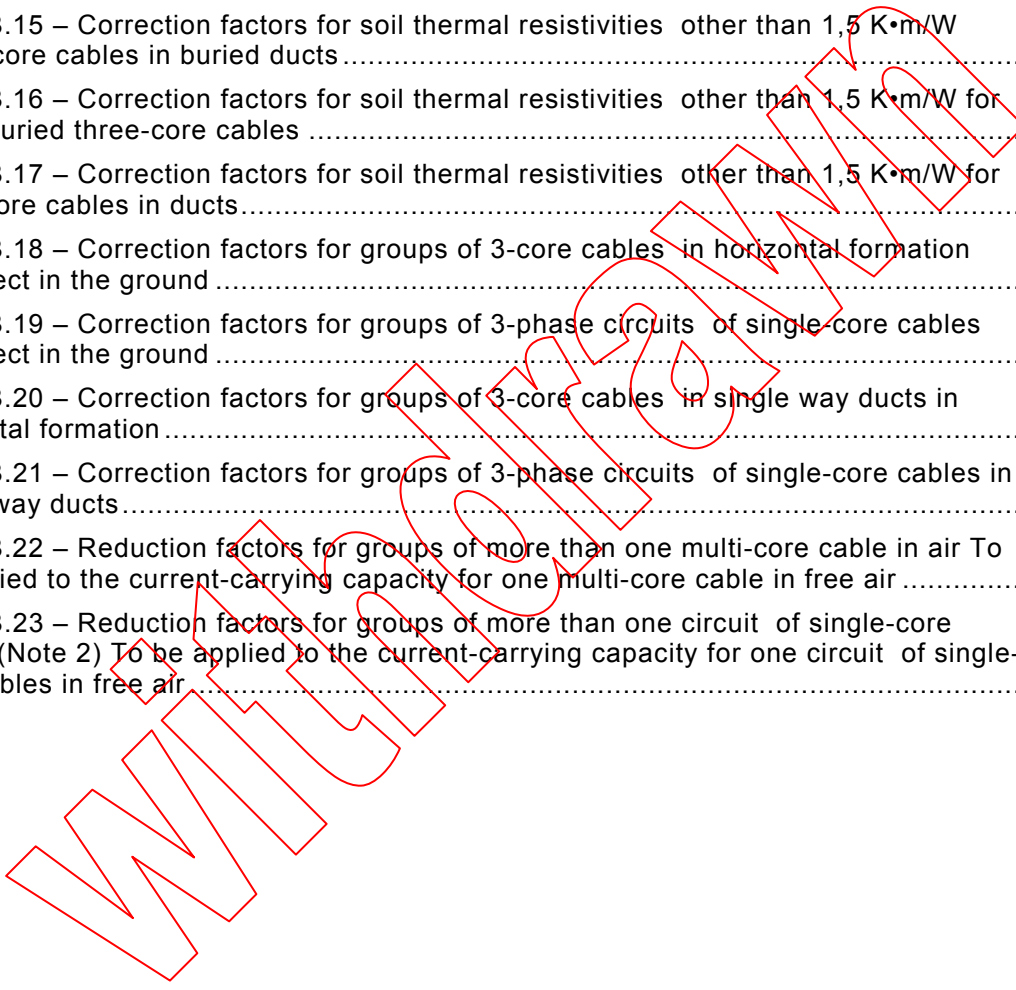
FOREWORD .....	13
1 Scope .....	17
2 Normative references .....	17
3 Terms and definitions .....	19
3.1 Definitions of dimensional values (thicknesses, cross-sections, etc.) .....	19
3.2 Definitions concerning the tests .....	21
4 Voltage designations and materials .....	21
4.1 Rated voltages .....	21
4.2 Insulating compounds .....	23
4.3 Sheathing compounds .....	25
5 Conductors .....	27
6 Insulation .....	27
6.1 Material .....	27
6.2 Insulation thickness .....	27
7 Screening .....	29
7.1 Conductor screen .....	31
7.2 Insulation screen .....	31
8 Assembly of three-core cables, inner coverings and fillers .....	31
8.1 Inner coverings and fillers .....	31
8.2 Cables having a collective metallic layer (see Clause 9) .....	33
8.3 Cables having a metallic layer over each individual core (see Clause 10) .....	33
9 Metallic layers for single-core and three-core cables .....	35
10 Metallic screen .....	35
10.1 Construction .....	35
10.2 Requirements .....	35
10.3 Metallic screens not associated with semi-conducting layers .....	35
11 Concentric conductor .....	35
11.1 Construction .....	35
11.2 Requirements .....	37
11.3 Application .....	37
12 Metallic sheath .....	37
12.1 Lead sheath .....	37
12.2 Other metallic sheaths .....	37
13 Metallic armour .....	37
13.1 Types of metallic armour .....	37
13.2 Materials .....	39
13.3 Application of armour .....	39
13.4 Dimensions of the armour wires and armour tapes .....	41
13.5 Correlation between cable diameters and armour dimensions .....	41
13.6 Round or flat wire armour .....	43
13.7 Double tape armour .....	43

14	Oversheath .....	43
14.1	General.....	43
14.2	Material.....	45
14.3	Thickness.....	45
15	Test conditions.....	45
15.1	Ambient temperature .....	45
15.2	Frequency and waveform of power frequency test voltages .....	45
15.3	Waveform of impulse test voltages.....	45
16	Routine tests.....	47
16.1	General.....	47
16.2	Electrical resistance of conductors.....	47
16.3	Partial discharge test.....	47
16.4	Voltage test.....	47
17	Sample tests .....	49
17.1	General.....	49
17.2	Frequency of sample tests .....	51
17.3	Repetition of tests .....	51
17.4	Conductor examination.....	51
17.5	Measurement of thickness of insulation and of non-metallic sheaths (including extruded separation sheaths, but excluding inner extruded coverings) .....	51
17.6	Measurement of thickness of lead sheath .....	53
17.7	Measurement of armour wires and tapes.....	55
17.8	Measurement of external diameter.....	55
17.9	Voltage test for 4 h.....	55
17.10	Hot set test for EPR, HEPR and XLPE insulations and elastomeric sheaths.....	57
18	Type tests, electrical .....	57
18.1	Cables having conductor screens and insulation screens .....	57
18.2	Cables of rated voltage 3,6/6 (7,2) kV having unscreened insulation .....	65
19	Type tests, non-electrical.....	69
19.1	Measurement of thickness of insulation.....	69
19.2	Measurement of thickness of non-metallic sheaths (including extruded separation sheaths, but excluding inner coverings) .....	69
19.3	Tests for determining the mechanical properties of insulation before and after ageing.....	69
19.4	Tests for determining the mechanical properties of non-metallic sheaths before and after ageing .....	71
19.5	Additional ageing test on pieces of completed cables.....	71
19.6	Loss of mass test on PVC sheaths of type ST <sub>2</sub> .....	73
19.7	Pressure test at high temperature on insulations and non-metallic sheaths.....	73
19.8	Test on PVC insulation and sheaths at low temperatures .....	73
19.9	Test for resistance of PVC insulation and sheaths to cracking (heat shock test) .....	73
19.10	Ozone resistance test for EPR and HEPR insulations.....	75
19.11	Hot set test for EPR, HEPR and XLPE insulations and elastomeric sheaths.....	75
19.12	Oil immersion test for elastomeric sheaths.....	75
19.13	Water absorption test on insulation.....	75

19.14	Flame spread test on single cables .....	75
19.15	Measurement of carbon black content of black PE oversheaths .....	75
19.16	Shrinkage test for XLPE insulation .....	77
19.17	Thermal stability test for PVC insulation .....	77
19.18	Determination of hardness of HEPR insulation .....	77
19.19	Determination of the elastic modulus of HEPR insulation .....	77
19.20	Shrinkage test for PE oversheaths .....	77
19.21	Strippability test for insulation screen .....	79
19.22	Water penetration test .....	79
20	Electrical tests after installation .....	81
20.1	D.C. voltage test of the oversheath .....	81
20.2	Insulation test .....	81
Annex A	(normative) Fictitious calculation method for determination of dimensions of protective coverings .....	93
Annex B	(informative) Tabulated continuous current ratings for cables having extruded insulation and a rated voltage from 3,6/6 kV up to 18/30 kV .....	103
Annex C	(normative) Rounding of numbers .....	143
Annex D	(normative) Method of measuring resistivity of semi-conducting screens .....	145
Annex E	(normative) Determination of hardness of HEPR insulations .....	149
Annex F	(normative) Water penetration test .....	153
Bibliography	.....	157
Figure B.1	– Single-core cables in air .....	105
Figure B.2	– Single-core cables buried direct .....	107
Figure B.3	– Single-core cables in earthenware ducts .....	107
Figure B.4	– Three-core cables .....	109
Figure D.1a	– Measurement of the volume resistivity of the conductor screen .....	147
Figure D.1b	– Measurement of the volume resistivity of the insulation screen .....	147
Figure D.1	– Preparation of samples for measurement of resistivity of conductor and insulation screens .....	147
Figure E.1	– Test on surfaces of large radius of curvature .....	151
Figure E.2	– Test on surfaces of small radius of curvature .....	151
Figure F.1	– Schematic diagram of apparatus for water penetration test .....	155
Table 1	– Recommended rated voltages $U_0$ .....	23
Table 2	– Insulating compounds .....	25
Table 3	– Maximum conductor temperatures for different types of insulating compound .....	25
Table 4	– Maximum conductor temperatures for different types of sheathing compound .....	27
Table 5	– Nominal thickness of PVC/B insulation .....	27
Table 6	– Nominal thickness of cross-linked polyethylene (XLPE) insulation .....	29

Table 7 – Nominal thickness of ethylene propylene rubber (EPR) and hard ethylene propylene rubber (HEPR) insulation .....	29
Table 8 – Thickness of extruded inner covering .....	33
Table 9 – Nominal diameter of round armour wires .....	41
Table 10 – Nominal thickness of armour tapes .....	43
Table 11 – Routine test voltages .....	49
Table 12 – Number of samples for sample tests .....	51
Table 13 – Sample test voltages .....	57
Table 14 – Impulse voltages .....	63
Table 15 – Electrical type test requirements for insulating compounds .....	81
Table 16 – Non-electrical type tests (see Tables 17 to 23) .....	83
Table 17 – Test requirements for mechanical characteristics of insulating compounds (before and after ageing) .....	85
Table 18 – Test requirements for particular characteristics for PVC insulating compound .....	85
Table 19 – Test requirements for particular characteristics of various thermosetting insulating compounds .....	87
Table 20 – Test requirements for mechanical characteristics of sheathing compounds (before and after ageing) .....	87
Table 21 – Test requirements for particular characteristics for PVC sheathing compounds .....	89
Table 22 – Test requirements for particular characteristics of PE (thermoplastic polyethylene) sheathing compounds .....	89
Table 23 – Test requirements for particular characteristics of elastomeric sheathing compound .....	91
Table A.1 – Fictitious diameter of conductor .....	95
Table A.2 – Increase of diameter for concentric conductors and metallic screens .....	97
Table A.3 – Increase of diameter for additional bedding .....	101
Table B.1 – Nominal screen cross-sectional areas .....	103
Table B.2 – Current ratings for single-core cables with XLPE insulation Rated voltage 3,6/6 kV to 18/30 kV * Copper conductor .....	111
Table B.3 – Current ratings for single-core cables with XLPE insulation Rated voltage 3,6/6 kV to 18/30 kV * Aluminium conductor .....	113
Table B.4 – Current ratings for single-core cables with EPR insulation Rated voltage 3,6/6 kV to 18/30 kV * Copper conductor .....	115
Table B.5 – Current ratings for single-core cables with EPR insulation Rated voltage 3,6/6 kV to 18/30 kV * Aluminium conductor .....	117
Table B.6 – Current rating for three-core XLPE insulated cables Rated voltage 3,6/6 kV to 18/30 kV * Copper conductor Armoured and unarmoured .....	119
Table B.7 – Current rating for three-core XLPE insulated cables Rated voltage 3,6/6 kV to 18/30 kV * Aluminium conductor Armoured and unarmoured .....	121
Table B.8 – Current rating for three-core EPR insulated cables Rated voltage 3,6/6 kV to 18/30 kV * Copper conductor Armoured and unarmoured .....	123

Table B.9 – Current rating for three-core EPR insulated cables Rated voltage 3,6/6 kV to 18/30 kV * Aluminium conductor Armoured and unarmoured.....	125
Table B.10 – Correction factors for ambient air temperatures other than 30 °C .....	127
Table B.11 – Correction factors for ambient ground temperatures other than 20 °C .....	127
Table B.12 – Correction factors for depths of laying other than 0,8 m for direct buried cables .....	127
Table B.13 – Correction factors for depths of laying other than 0,8 m for cables in ducts .....	129
Table B.14 – Correction factors for soil thermal resistivities other than 1,5 K•m/W for direct buried single-core cables .....	129
Table B.15 – Correction factors for soil thermal resistivities other than 1,5 K•m/W single-core cables in buried ducts .....	131
Table B.16 – Correction factors for soil thermal resistivities other than 1,5 K•m/W for direct buried three-core cables .....	131
Table B.17 – Correction factors for soil thermal resistivities other than 1,5 K•m/W for three-core cables in ducts.....	133
Table B.18 – Correction factors for groups of 3-core cables in horizontal formation laid direct in the ground .....	133
Table B.19 – Correction factors for groups of 3-phase circuits of single-core cables laid direct in the ground .....	135
Table B.20 – Correction factors for groups of 3-core cables in single way ducts in horizontal formation .....	135
Table B.21 – Correction factors for groups of 3-phase circuits of single-core cables in single-way ducts.....	137
Table B.22 – Reduction factors for groups of more than one multi-core cable in air To be applied to the current-carrying capacity for one multi-core cable in free air .....	139
Table B.23 – Reduction factors for groups of more than one circuit of single-core cables (Note 2) To be applied to the current-carrying capacity for one circuit of single-core cables in free air .....	141



## 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 International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60502-2 has been prepared by IEC technical committee 20: Electric cables.

This second edition cancels and replaces the first edition published in 1997, its amendment 1 (1998) and its corrigendum 1 (1999) and constitutes a technical revision.

Significant technical changes with respect to the first edition have been made. The changes relate to possible water ingress, large conductor sizes, partial discharge requirements, insulation and oversheath thickness requirements, range of type approval, electrical tests after installation and tabulated current ratings.



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).

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

FDIS	Report on voting
20/749/FDIS	20/763/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.

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.

# **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.

When determining applications, it is recommended that the possible risk of radial water ingress is considered. Cable designs with barriers claimed to prevent longitudinal water penetration and an associated test are included in this part of IEC 60502.

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) nor for submarine use or shipboard application.

### **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, *IEC standard voltages*

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

IEC 60183, *Guide to the selection of high-voltage cables*

IEC 60228, *Conductors of insulated cables*

IEC 60229, *Tests on cable oversheaths which have a special protective function and are applied by extrusion*

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

IEC 60811-1-2, *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, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1-3: General application – Methods for determining the density – Water absorption tests – Shrinkage test*

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

IEC 60811-2-1, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 2-1: Methods specific to elastomeric compounds – Ozone resistance, hot set and mineral oil immersion tests*

IEC 60811-3-1, *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, *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, *Insulating and sheathing materials of electric and optical cables – Common test methods – Part 4-1: Methods specific to polyethylene and polypropylene compounds – Resistance to environmental stress cracking – Measurement of the melt flow index – Carbon black and/or mineral filler content measurement in polyethylene by direct combustion – Measurement of carbon black content by thermogravimetric analysis (TGA) – Assessment of carbon black dispersion in polyethylene using a microscope*

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

IEC 60986, *Short-circuit temperature limits of electric cables with rated voltages from 6 kV ( $U_m$  7,2 kV) up to 30 kV ( $U_m$  =36 kV)*

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