IEC 60840

Edition 5.1 2023-06
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

Corrected version
2025-06

colour inside

Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-7126-1

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

IEC 60840

Edition 5.1 2023-06
CONSOLIDATED VERSION

REDLINE VERSION

Corrected version
2025-06

colour inside

Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements



IEC 60840: 2020-05+AMD1:2023-06 CSV(en)

CONTENTS

FOREWORD 8
INTRODUCTION 10
1 Scope 11
2 Normative references 11
3 Terms and definitions 13
3.1 Definitions of dimensional values (thicknesses, cross-sections, etc.) 13
3.2 Definitions concerning tests 14
3.3 Other definitions 14
4 Voltage designations, materials and rounding of numbers 16
4.1 Rated voltages 16
4.2 Cable insulating compounds 16
4.3 Cable metal screens/sheaths 16
4.4 Cable oversheathing compounds 16
4.5 Rounding of numbers 17
5 Precautions against water penetration in cables 17
6 Cable characteristics 17
7 Accessories characteristics 18
7.1 Gas immersed cable terminations 18
7.2 ~~Composite~~ Insulators for outdoor cable terminations 18
7.3 Accessory characteristics to be declared 19
8 Test conditions 20
8.1 Ambient temperature 20
8.2 High voltage tests 20
8.3 Waveform of lightning impulse test voltages 20
8.4 Relationship of test voltages to rated voltages 20
8.5 Determination of the cable conductor temperature 20
8.6 Tests on gas immersed terminations 20
9 Routine tests on cables and accessories 21
9.1 General 21
9.2 Partial discharge test 21
9.3 Voltage test 21
9.4 Electrical test on oversheath of the cable 22
10 Sample tests on cables 22
10.1 General 22
10.2 Frequency of tests 22
10.3 Repetition of tests 22
10.4 Conductor examination 23
10.5 Measurement of electrical resistance of conductor and metal screen 23
10.6 Measurement of thickness of cable insulation and oversheath 23
10.6.1 General 23
10.6.2 Requirements for the insulation 23
10.6.3 Requirements for the cable oversheath 24
10.7 Measurement of thickness of metal sheath 24
10.7.1 General 24
10.7.2 Lead or lead alloy sheath 24
10.7.3 Copper or aluminium sheath 25

10.7.4 Metal tape for CD design 25
10.8 Measurement of diameters 25
10.9 Hot set test for XLPE, EPR and HEPR insulations 26
10.9.1 Procedure 26
10.9.2 Requirements 26
10.10 Measurement of capacitance 26
10.11 Measurement of density of HDPE insulation 26
10.11.1 Procedure 26
10.11.2 Requirements 26
10.12 Lightning impulse voltage test 26
10.13 Water penetration test 27
10.14 ~~Additional~~ Tests on components of cables with a longitudinally applied metal tape or foil~~,~~ bonded to the oversheath 27
11 Sample tests on accessories 27
11.1 Tests on components of accessory 27
11.2 Tests on complete accessory 27
12 Type tests on cable systems 27
12.1 General 27
12.2 Range of type approval 28
12.3 Summary of type tests 29
12.4 Electrical type tests on cable systems 30
12.4.1 Test voltage values 30
12.4.2 Tests and sequence of tests 30
12.4.3 Bending test 30
12.4.4 Partial discharge tests 31
12.4.5 Tan δ measurement 31
12.4.6 Heating cycle voltage test 32
12.4.7 Lightning impulse voltage test followed by a power frequency voltage test 32
12.4.8 Examination 33
12.4.9 Resistivity of semi-conducting screens 33
12.5 Non-electrical type tests on cable components and on complete cable 34
12.5.1 General 34
12.5.2 Check of cable construction 34
12.5.3 Tests for determining the mechanical properties of insulation before and after ageing 34
12.5.4 Tests for determining the mechanical properties of oversheaths before and after ageing 35
12.5.5 Ageing tests on pieces of complete cable to check compatibility of materials 35
12.5.6 Loss of mass test on PVC oversheaths of type ST_2 36
12.5.7 Pressure test at high temperature on oversheaths 36
12.5.8 Test ~~on~~ for PVC oversheaths (ST_1, ST_2) and LSHF oversheaths (ST_{12}) at low temperature 36
12.5.9 Heat shock test for PVC oversheaths (ST_1 and ST_2) 37
12.5.10 Ozone resistance test for EPR and HEPR insulations 37
12.5.11 Hot set test for EPR, HEPR and XLPE insulations 37
12.5.12 Measurement of density of HDPE insulation 37

12.5.13 Measurement of carbon black content ~~of~~ for black PE oversheaths (ST_3 and ST_7) 37
12.5.14 Test under fire conditions 38
12.5.15 Water penetration test 40
12.5.16 Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath 40
12.5.17 Shrinkage test for PE, HDPE and XLPE insulations 40
12.5.18 Shrinkage test for PE oversheaths (ST_3, ST_7) and LSHF oversheaths (ST_{12}) 41
12.5.19 Determination of hardness of HEPR insulation 41
12.5.20 Determination of the elastic modulus of HEPR insulation 41
13 Prequalification test of the cable system 41
13.1 General and range of prequalification test approval 41
13.2 Prequalification test on complete system 42
13.2.1 Summary of prequalification tests 42
13.2.2 Test voltage values 43
13.2.3 Test arrangement 43
13.2.4 Heating cycle voltage test 44
13.2.5 Lightning impulse voltage test 44
13.2.6 Examination 45
13.3 Tests for the extension of the prequalification of a cable system 45
13.3.1 Summary of the extension of prequalification test 45
13.3.2 Electrical part of the extension of prequalification tests on complete cable system 45
14 Type tests on cables 47
14.1 General 47
14.2 Range of type approval 48
14.3 Summary of type tests 48
14.4 Electrical type tests on completed cables 49
15 Type tests on accessories 49
15.1 General 49
15.2 Range of type approval 49
15.3 Summary of type tests 50
15.4 Electrical type tests on accessories 51
15.4.1 Test voltage values 51
15.4.2 Tests and sequence of tests 51
16 Electrical tests after installation (on-site tests) 51
16.1 General 51
16.2 DC voltage test of the oversheath 51
16.3 Tests using AC voltage ~~test of the insulation~~ 52
Annex A (informative) Determination of the cable conductor temperature 62
A.1 Purpose 62
A.2 Calibration of the temperature of the main test loop 62
A.2.1 General 62
A.2.2 Installation of cable and temperature sensors 62
A.2.3 Calibration method 64
A.3 Heating for the test 64
A.3.1 Method 1 – Test using a reference cable 64

A.3.2 Method 2 – Test using conductor temperature calculations and measurement of the surface temperature 65
Annex B (normative) Rounding of numbers 66
Annex C (informative) List of type, prequalification and extension of prequalification tests for cable systems, cables and accessories 67
Annex D (normative) Method of measuring resistivity of semi-conducting screens 70
Annex E (normative) Water penetration test 73
E.1 Test piece 73
E.2 Test 73
E.3 Requirements 74
Annex F (normative) Test for water penetration in the conductor 76
F.1 Test piece 76
F.2 Test 76
F.3 Requirements 76
Annex G (normative) Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath 79
G.1 Visual examination 79
G.2 Adhesion and peel strength 79
G.2.1 General 79
G.2.2 Test: Adhesion strength 79
G.2.3 Test: Peel strength of overlapped metal foil 80
G.2.4 Requirements 81
Annex H (normative) Additional tests for accessories 83
H.1 General 83
H.2 Range of approval 85
H.2.1 Range of approval for joints without screen or metal sheath interruption 85
H.2.2 Range of approval for joints with screen or metal sheath interruption 86
H.2.3 Range of approval for accessories for cable screen interruption and/or earth connection 86
H.2.4 Range of approval for terminations with ~~sectionalizing insulation~~ an insulated screen 86
H.3 Tests of joints with or without screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection 86
H.3.1 Conditioning of sample for test 86
H.3.2 Water immersion test 86
H.3.3 Electrical tests 87
H.3.4 Examination 88
H.4 Tests of terminations with ~~sheath sectionalizing insulation~~ an insulated screen 89
H.4.1 Conditioning of sample for test 89
H.4.2 DC voltage withstand test between screen and earth 89
H.4.3 Lightning impulse voltage withstand test between screen and earth 89
H.4.4 Examination 89
H.5 Tests for ~~composite~~ insulators for outdoor terminations 90
H.5.1 Tests for ceramic insulators 90
H.5.2 Tests for composite insulators 90
H.6 Tests for gas-immersed terminations in case of changing insulating gas 90
H.6.1 General 90
H.6.2 Electrical tests 91

H.6.3 Leak rate test 91
Annex I (normative) Determination of hardness of HEPR insulations 92
I.1 Test piece 92
I.2 Test procedure 92
I.2.1 General 92
I.2.2 Surfaces of large radius of curvature 92
I.2.3 Surfaces of small radius of curvature 92
I.2.4 Conditioning and test temperature 92
I.2.5 Number of measurements 93
Annex J (informative) Guidance on examination of cable and accessories 94
Annex K (~~xxx~~ informative) ~~Void~~ Guidance for type test on heating-cycle-voltage-test interruption and cycle validity 95
K.1 Interruption of cycles during a heating cycle voltage test 95
K.1.1 Scheduled interruption of test 95
K.1.2 Non-scheduled interruption of test 95
K.2 Valid heating cycles 95
Annex L (normative) Methods for determining the weighted value of halogen content of the non-metallic materials in the cable 96
L.1 Calculating the weighted value of the cable when the halogen content of individual materials is tested 96
L.2 Preparation of the test sample for measurement of halogen content on a sample representative of the non-metallic materials in the cable 96
Bibliography 97

Figure 1 – Example of the test arrangement for the prequalification test 44
Figure 2 – Example of extension of prequalification test arrangement for the prequalification of a system with another joint, designed for rigid as well as flexible installation 46
Figure A.1 – Typical test set-up for the reference loop and the main test loop 63
Figure A.2 – Example of an arrangement of the temperature sensors on the conductor of the reference loop 64
Figure D.1 – Preparation of samples for measurement of resistivity of conductor and insulation screens 72
Figure E.1 – Schematic diagram of apparatus for water penetration test 75
Figure F.1 – Schematic diagram of apparatus for water penetration test in the conductor 78
Figure G.1 – Adhesion of metal tape or foil 80
Figure G.2 – Example of overlapped metal foil 81
Figure G.3 – Peel strength of overlapped metal foil 81
Figure G.4 – Typical strength versus grip spacing curve (1) 82
Figure G.5 – Typical strength versus grip spacing curve (2) 82
Figure I.1 – Test on surfaces of large radius of curvature 93
Figure I.2 – Test on surfaces of small radius of curvature 93

Table 1 – Insulating compounds for cables 53
Table 2 – Oversheathing compounds for cables 53
Table 3 – Tan δ requirements for insulating compounds for cables 54
Table 4 – Test voltages 54

Table 5 – Non-electrical type tests for insulating and oversheathing compounds for cables 55

Table 6 – Test requirements for mechanical characteristics of insulating compounds for cables (before and after ageing) 56

Table 7 – Test requirements for mechanical characteristics of oversheathing compounds for cables (before and after ageing) 57

Table 8 – Test requirements for particular characteristics of insulating compounds for cables 58

Table 9 – Test requirements for particular characteristics of PVC and LSHF oversheathing for cables 59

Table 11 – Test requirements for fire performance characteristics of cables with PVC and LSHF oversheaths 60

Table 10 – ~~Maximum mechanical~~ Cantilever operating load for ~~composite~~ insulators for outdoor terminations 61

Table 12 – Test voltages for AC voltage test after installation 61

Table C.1 – Type tests on cable systems, on cables and on accessories 67

Table C.2 – Prequalification tests on cable systems with a calculated nominal conductor electric stress above 8,0 kV/mm or a calculated nominal insulation electric stress above 4,0 kV/mm 68

Table C.3 – ~~Extension of prequalification~~ EQ tests on cable systems with a calculated nominal conductor electric stress above 8,0 kV/mm or a calculated nominal insulation electric stress above 4,0 kV/mm 69

Table G.1 – Minimum acceptable adhesion or peel strength forces 82

Table H.1 – Test sequence 84

Table H.2 – Lightning impulse voltage withstand test between screen and earth of joints with or without screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection 88

Table H.3 – Lightning impulse voltage withstand test between screen and screen of joints with screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection 88

Table H.4 – Lightning impulse voltage withstand tests between screen and earth of terminations with ~~sheath sectionalizing insulation~~ an insulated screen 89

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES ABOVE 30 kV (U_m = 36 kV) UP TO 150 kV (U_m = 170 kV) – TEST METHODS AND REQUIREMENTS

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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
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.

This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60840 edition 5.1 contains the fifth edition (2020-05) [documents 20/1909/FDIS and 20/1910/RVD] and its corrigendum 1 (2021-02), as well as its amendment 1 (2023-06) [documents 20/2100/FDIS and 20/2107/RVD] and its corrigendum 1 (2025-06).

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60840 has been prepared by IEC technical committee 20: Electric cables.

This fifth edition constitutes a technical revision.

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

- Gas immersed cable terminations for use at rated voltages above 52 kV are required to be designed, type and routine tested in accordance with IEC 62271-209 in addition to the routine and type tests specified in this document.
- Requirements are introduced for composite outdoor termination insulators.
- The test cylinder diameters specified for the bending test (type and prequalification tests) have been modified in line with IEC TR 61901:2016.
- A low smoke halogen free oversheath material, designated ST_{12} is introduced.
- Additional tests under fire conditions are introduced: vertical flame spread, smoke density, acidity and conductivity, which shall be applied according to the fire performance declared for the cable.
- A test for water penetration in the conductor is added.
- In addition to tests on the outer protection of joints, type tests on the screen sectionalizing insulation of all accessories have been introduced.

NOTE For a more detailed history of events leading up to this fifth edition, see the Introduction.

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

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

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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The first edition of IEC 60840, published in 1988, dealt only with cables. Accessories were added to the second edition, published in February 1999, which separately covered test methods and test requirements for

a) cables alone,

b) cables together with accessories (a cable system).

Some countries then suggested that a better discrimination be made between systems, cables and accessories, particularly for the lower voltages of the scope, for example 45 kV. This was taken into account in the third edition (2004) and has been retained subsequently, giving the type approval requirements and the range of approvals for:

a) cable systems,

b) cables alone,

c) accessories alone.

Manufacturers and users may choose the most appropriate option for type approval.

The fourth edition (2011) introduced the prequalification test procedure, as a cable system inclusive of accessories, for cables with high electrical stresses at the conductor screen and/or insulation screen.

Other significant changes in the fourth edition were:

a) The clause numbering of this document and IEC 62067 was coordinated to achieve as much commonality as possible.

b) In the case of the sample test, the lightning impulse voltage test is no longer followed by a power frequency voltage test.

In this fifth edition the principle changes are as follows:

a) New definitions have been added for three different cable screen designs following IEC TR 61901:2016.

b) Gas immersed cable terminations for use at rated voltages above 52 kV are required to be designed, type and routine tested in accordance with IEC 62271-209 in addition to the routine and type tests specified in this document.

c) Requirements are introduced for composite outdoor termination insulators.

d) The test cylinder diameters specified for the bending test (type and prequalification tests) have been modified in line with IEC TR 61901:2016.

e) A low smoke halogen free oversheath material, designated ST_{12} is introduced.

f) Additional tests under fire conditions are introduced: vertical flame spread, smoke density, acidity and conductivity, which are applied according to the fire performance declared for the cable.

g) A test for water penetration in the conductor is added.

h) In addition to tests on the outer protection of joints, type tests on the screen sectionalizing insulation of all accessories have been introduced.

i) A list of relevant CIGRE references is given in the bibliography.

POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES ABOVE 30 kV (U_m = 36 kV) UP TO 150 kV (U_m = 170 kV) – TEST METHODS AND REQUIREMENTS

1 Scope

This document specifies test methods and requirements for power cable systems, cables alone and accessories alone, for fixed installations and for rated voltages above 30 kV (U_m = 36 kV) up to and including 150 kV (U_m = 170 kV).

The requirements apply to single-core cables and to individually screened three-core cables and to their accessories for usual conditions of installation and operation, but not to special cables, such as submarine cables and their accessories, for which modifications to the standard tests or the setup of special test conditions can be necessary.

This document does not cover transition joints between cables with extruded insulation and paper insulated cables.

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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-3, *High-voltage test techniques – Part 3: Definitions and requirements for on-site testing*

IEC 60137, *Insulated bushings for alternating voltages above 1 000 V*

IEC 60228, *Conductors of insulated cables*

IEC 60229:2007, *Electric cables – Tests on extruded oversheaths with a special protective function*

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

IEC 60287-1-1:2006, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*

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 60332-1-3, *Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles*

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

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

IEC 60754-3, *Test on gases evolved during combustion of materials from cables – Part 3: Measurement of low level of halogen content by ion chromatography*

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

IEC 60811-202:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*
IEC 60811-202:2012/AMD1:2017

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

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

IEC 60811-409, *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 60811-501:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulation and sheathing compounds*
IEC 60811-501:2012/AMD1:2018

IEC 60811-502:2012, *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 60811-505, *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 60811-508:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulations and sheaths*
IEC 60811-508:2012/AMD1:2017

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 60811-605:2012, *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 60885-3, *Electrical test methods for electric cables – Part 3: Test methods for partial discharge measurements on lengths of extruded power cables*

IEC 61034-2:2005, *Measurement of smoke density of cables burning under defined conditions –Part 2: Test procedure and requirements*
IEC 61034-2:2005/AMD1:2013

IEC 61462:2007, *Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods, acceptance criteria and design recommendations*

IEC 62155, *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*

IEC 62271-209, *High-voltage switchgear and controlgear – Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV. Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable-terminations*

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

IEC 60840

Edition 5.1 2023-06
CONSOLIDATED VERSION

FINAL VERSION

Corrected version
2025-06

Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements



IEC 60840: 2020-05+AMD1:2023-06 CSV(en)

CONTENTS

FOREWORD 8
INTRODUCTION 10
1 Scope 11
2 Normative references 11
3 Terms and definitions 13
3.1 Definitions of dimensional values (thicknesses, cross-sections, etc.) 13
3.2 Definitions concerning tests 14
3.3 Other definitions 14
4 Voltage designations, materials and rounding of numbers 16
4.1 Rated voltages 16
4.2 Cable insulating compounds 16
4.3 Cable metal screens/sheaths 16
4.4 Cable oversheathing compounds 16
4.5 Rounding of numbers 17
5 Precautions against water penetration in cables 17
6 Cable characteristics 17
7 Accessories characteristics 18
7.1 Gas immersed cable terminations 18
7.2 Insulators for outdoor cable terminations 18
7.3 Accessory characteristics to be declared 19
8 Test conditions 20
8.1 Ambient temperature 20
8.2 High voltage tests 20
8.3 Waveform of lightning impulse test voltages 20
8.4 Relationship of test voltages to rated voltages 20
8.5 Determination of the cable conductor temperature 20
8.6 Tests on gas immersed terminations 20
9 Routine tests on cables and accessories 20
9.1 General 20
9.2 Partial discharge test 21
9.3 Voltage test 21
9.4 Electrical test on oversheath of the cable 21
10 Sample tests on cables 22
10.1 General 22
10.2 Frequency of tests 22
10.3 Repetition of tests 22
10.4 Conductor examination 22
10.5 Measurement of electrical resistance of conductor and metal screen 22
10.6 Measurement of thickness of cable insulation and oversheath 23
10.6.1 General 23
10.6.2 Requirements for the insulation 23
10.6.3 Requirements for the cable oversheath 23
10.7 Measurement of thickness of metal sheath 24
10.7.1 General 24
10.7.2 Lead or lead alloy sheath 24
10.7.3 Copper or aluminium sheath 24

10.7.4 Metal tape for CD design 25
10.8 Measurement of diameters 25
10.9 Hot set test for XLPE, EPR and HEPR insulations 25
10.9.1 Procedure 25
10.9.2 Requirements 25
10.10 Measurement of capacitance 25
10.11 Measurement of density of HDPE insulation 26
10.11.1 Procedure 26
10.11.2 Requirements 26
10.12 Lightning impulse voltage test 26
10.13 Water penetration test 26
10.14 Tests on components of cables with a longitudinally applied metal tape or foil bonded to the oversheath 26
11 Sample tests on accessories 26
11.1 Tests on components of accessory 26
11.2 Tests on complete accessory 27
12 Type tests on cable systems 27
12.1 General 27
12.2 Range of type approval 27
12.3 Summary of type tests 28
12.4 Electrical type tests on cable systems 29
12.4.1 Test voltage values 29
12.4.2 Tests and sequence of tests 29
12.4.3 Bending test 30
12.4.4 Partial discharge tests 31
12.4.5 Tan δ measurement 31
12.4.6 Heating cycle voltage test 31
12.4.7 Lightning impulse voltage test followed by a power frequency voltage test 32
12.4.8 Examination 32
12.4.9 Resistivity of semi-conducting screens 33
12.5 Non-electrical type tests on cable components and on complete cable 33
12.5.1 General 33
12.5.2 Check of cable construction 34
12.5.3 Tests for determining the mechanical properties of insulation before and after ageing 34
12.5.4 Tests for determining the mechanical properties of oversheaths before and after ageing 34
12.5.5 Ageing tests on pieces of complete cable to check compatibility of materials 35
12.5.6 Loss of mass test on PVC oversheaths of type ST_2 35
12.5.7 Pressure test at high temperature on oversheaths 35
12.5.8 Test for PVC oversheaths (ST_1, ST_2) and LSHF oversheaths (ST_{12}) at low temperature 36
12.5.9 Heat shock test for PVC oversheaths (ST_1 and ST_2) 36
12.5.10 Ozone resistance test for EPR and HEPR insulations 36
12.5.11 Hot set test for EPR, HEPR and XLPE insulations 36
12.5.12 Measurement of density of HDPE insulation 36

12.5.13 Measurement of carbon black content for black PE oversheaths (ST_3 and ST_7) 37
12.5.14 Test under fire conditions 37
12.5.15 Water penetration test 38
12.5.16 Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath 39
12.5.17 Shrinkage test for PE, HDPE and XLPE insulations 39
12.5.18 Shrinkage test for PE oversheaths (ST_3, ST_7) and LSHF oversheaths (ST_{12}) 39
12.5.19 Determination of hardness of HEPR insulation 39
12.5.20 Determination of the elastic modulus of HEPR insulation 39
13 Prequalification test of the cable system 40
13.1 General and range of prequalification test approval 40
13.2 Prequalification test on complete system 41
13.2.1 Summary of prequalification tests 41
13.2.2 Test voltage values 41
13.2.3 Test arrangement 41
13.2.4 Heating cycle voltage test 42
13.2.5 Lightning impulse voltage test 43
13.2.6 Examination 43
13.3 Tests for the extension of the prequalification of a cable system 43
13.3.1 Summary of the extension of prequalification test 43
13.3.2 Electrical part of the extension of prequalification tests on complete cable system 43
14 Type tests on cables 45
14.1 General 45
14.2 Range of type approval 46
14.3 Summary of type tests 46
14.4 Electrical type tests on completed cables 46
15 Type tests on accessories 47
15.1 General 47
15.2 Range of type approval 47
15.3 Summary of type tests 48
15.4 Electrical type tests on accessories 48
15.4.1 Test voltage values 48
15.4.2 Tests and sequence of tests 48
16 Electrical tests after installation (on-site tests) 49
16.1 General 49
16.2 DC voltage test of the oversheath 49
16.3 Tests using AC voltage 49
Annex A (informative) Determination of the cable conductor temperature 59
A.1 Purpose 59
A.2 Calibration of the temperature of the main test loop 59
A.2.1 General 59
A.2.2 Installation of cable and temperature sensors 59
A.2.3 Calibration method 61
A.3 Heating for the test 61
A.3.1 Method 1 – Test using a reference cable 61

A.3.2 Method 2 – Test using conductor temperature calculations and measurement of the surface temperature 62
Annex B (normative) Rounding of numbers 63
Annex C (informative) List of type, prequalification and extension of prequalification tests for cable systems, cables and accessories 64
Annex D (normative) Method of measuring resistivity of semi-conducting screens 66
Annex E (normative) Water penetration test 69
E.1 Test piece 69
E.2 Test 69
E.3 Requirements 70
Annex F (normative) Test for water penetration in the conductor 71
F.1 Test piece 71
F.2 Test 71
F.3 Requirements 71
Annex G (normative) Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath 73
G.1 Visual examination 73
G.2 Adhesion and peel strength 73
G.2.1 General 73
G.2.2 Test: Adhesion strength 73
G.2.3 Test: Peel strength of overlapped metal foil 74
G.2.4 Requirements 75
Annex H (normative) Additional tests for accessories 77
H.1 General 77
H.2 Range of approval 78
H.2.1 Range of approval for joints without screen or metal sheath interruption 78
H.2.2 Range of approval for joints with screen or metal sheath interruption 79
H.2.3 Range of approval for accessories for cable screen interruption and/or earth connection 79
H.2.4 Range of approval for terminations with an insulated screen 79
H.3 Tests of joints with or without screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection 79
H.3.1 Conditioning of sample for test 79
H.3.2 Water immersion test 79
H.3.3 Electrical tests 80
H.3.4 Examination 81
H.4 Tests of terminations with an insulated screen 82
H.4.1 Conditioning of sample for test 82
H.4.2 DC voltage withstand test between screen and earth 82
H.4.3 Lightning impulse voltage withstand test between screen and earth 82
H.4.4 Examination 82
H.5 Tests for insulators for outdoor terminations 82
H.5.1 Tests for ceramic insulators 82
H.5.2 Tests for composite insulators 83
H.6 Tests for gas-immersed terminations in case of changing insulating gas 83
H.6.1 General 83
H.6.2 Electrical tests 83
H.6.3 Leak rate test 84
Annex I (normative) Determination of hardness of HEPR insulations 85

I.1 Test piece 85
I.2 Test procedure 85
I.2.1 General 85
I.2.2 Surfaces of large radius of curvature 85
I.2.3 Surfaces of small radius of curvature 85
I.2.4 Conditioning and test temperature 85
I.2.5 Number of measurements 86
Annex J (informative) Guidance on examination of cable and accessories 87
Annex K (informative) Guidance for type test on heating-cycle-voltage-test interruption and cycle validity 88
K.1 Interruption of cycles during a heating cycle voltage test 88
K.1.1 Scheduled interruption of test 88
K.1.2 Non-scheduled interruption of test 88
K.2 Valid heating cycles 88
Annex L (normative) Methods for determining the weighted value of halogen content of the non-metallic materials in the cable 89
L.1 Calculating the weighted value of the cable when the halogen content of individual materials is tested 89
L.2 Preparation of the test sample for measurement of halogen content on a sample representative of the non-metallic materials in the cable 89
Bibliography 90

Figure 1 – Example of the test arrangement for the prequalification test 42
Figure 2 – Example of extension of prequalification test arrangement for the prequalification of a system with another joint, designed for rigid as well as flexible installation 44
Figure A.1 – Typical test set-up for the reference loop and the main test loop 60
Figure A.2 – Example of an arrangement of the temperature sensors on the conductor of the reference loop 61
Figure D.1 – Preparation of samples for measurement of resistivity of conductor and insulation screens 68
Figure E.1 – Schematic diagram of apparatus for water penetration test 70
Figure F.1 – Schematic diagram of apparatus for water penetration test in the conductor 72
Figure G.1 – Adhesion of metal tape or foil 74
Figure G.2 – Example of overlapped metal foil 75
Figure G.3 – Peel strength of overlapped metal foil 75
Figure G.4 – Typical strength versus grip spacing curve (1) 76
Figure G.5 – Typical strength versus grip spacing curve (2) 76
Figure I.1 – Test on surfaces of large radius of curvature 86
Figure I.2 – Test on surfaces of small radius of curvature 86

Table 1 – Insulating compounds for cables 50
Table 2 – Oversheathing compounds for cables 50
Table 3 – Tan δ requirements for insulating compounds for cables 51
Table 4 – Test voltages 51
Table 5 – Non-electrical type tests for insulating and oversheathing compounds for cables 52

Table 6 – Test requirements for mechanical characteristics of insulating compounds for cables (before and after ageing) 53
Table 7 – Test requirements for mechanical characteristics of oversheathing compounds for cables (before and after ageing) 54
Table 8 – Test requirements for particular characteristics of insulating compounds for cables 55
Table 9 – Test requirements for particular characteristics of PVC and LSHF oversheathing for cables 56
Table 11 – Test requirements for fire performance characteristics of cables with PVC and LSHF oversheaths 57
Table 10 – Cantilever operating load for insulators for outdoor terminations 58
Table 12 – Test voltages for AC voltage test after installation 58
Table C.1 – Type tests on cable systems, on cables and on accessories 64
Table C.2 – Prequalification tests on cable systems with a calculated nominal conductor electric stress above 8,0 kV/mm or a calculated nominal insulation electric stress above 4,0 kV/mm 65
Table C.3 – EQ tests on cable systems with a calculated nominal conductor electric stress above 8,0 kV/mm or a calculated nominal insulation electric stress above 4,0 kV/mm 65
Table G.1 – Minimum acceptable adhesion or peel strength forces 76
Table H.1 – Test sequence 78
Table H.2 – Lightning impulse voltage withstand test between screen and earth of joints with or without screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection 81
Table H.3 – Lightning impulse voltage withstand test between screen and screen of joints with screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection 81
Table H.4 – Lightning impulse voltage withstand tests between screen and earth of terminations with an insulated screen 82

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES ABOVE 30 kV (U_m = 36 kV) UP TO 150 kV (U_m = 170 kV) – TEST METHODS AND REQUIREMENTS

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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
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.

This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60840 edition 5.1 contains the fifth edition (2020-05) [documents 20/1909/FDIS and 20/1910/RVD] and its corrigendum 1 (2021-02), as well as its amendment 1 (2023-06) [documents 20/2100/FDIS and 20/2107/RVD] and its corrigendum 1 (2025-06).

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 60840 has been prepared by IEC technical committee 20: Electric cables.

This fifth edition constitutes a technical revision.

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

- Gas immersed cable terminations for use at rated voltages above 52 kV are required to be designed, type and routine tested in accordance with IEC 62271-209 in addition to the routine and type tests specified in this document.
- Requirements are introduced for composite outdoor termination insulators.
- The test cylinder diameters specified for the bending test (type and prequalification tests) have been modified in line with IEC TR 61901:2016.
- A low smoke halogen free oversheath material, designated ST_{12} is introduced.
- Additional tests under fire conditions are introduced: vertical flame spread, smoke density, acidity and conductivity, which shall be applied according to the fire performance declared for the cable.
- A test for water penetration in the conductor is added.
- In addition to tests on the outer protection of joints, type tests on the screen sectionalizing insulation of all accessories have been introduced.

NOTE For a more detailed history of events leading up to this fifth edition, see the Introduction.

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

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

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

INTRODUCTION

The first edition of IEC 60840, published in 1988, dealt only with cables. Accessories were added to the second edition, published in February 1999, which separately covered test methods and test requirements for

a) cables alone,

b) cables together with accessories (a cable system).

Some countries then suggested that a better discrimination be made between systems, cables and accessories, particularly for the lower voltages of the scope, for example 45 kV. This was taken into account in the third edition (2004) and has been retained subsequently, giving the type approval requirements and the range of approvals for:

a) cable systems,

b) cables alone,

c) accessories alone.

Manufacturers and users may choose the most appropriate option for type approval.

The fourth edition (2011) introduced the prequalification test procedure, as a cable system inclusive of accessories, for cables with high electrical stresses at the conductor screen and/or insulation screen.

Other significant changes in the fourth edition were:

a) The clause numbering of this document and IEC 62067 was coordinated to achieve as much commonality as possible.

b) In the case of the sample test, the lightning impulse voltage test is no longer followed by a power frequency voltage test.

In this fifth edition the principle changes are as follows:

a) New definitions have been added for three different cable screen designs following IEC TR 61901:2016.

b) Gas immersed cable terminations for use at rated voltages above 52 kV are required to be designed, type and routine tested in accordance with IEC 62271-209 in addition to the routine and type tests specified in this document.

c) Requirements are introduced for composite outdoor termination insulators.

d) The test cylinder diameters specified for the bending test (type and prequalification tests) have been modified in line with IEC TR 61901:2016.

e) A low smoke halogen free oversheath material, designated ST_{12} is introduced.

f) Additional tests under fire conditions are introduced: vertical flame spread, smoke density, acidity and conductivity, which are applied according to the fire performance declared for the cable.

g) A test for water penetration in the conductor is added.

h) In addition to tests on the outer protection of joints, type tests on the screen sectionalizing insulation of all accessories have been introduced.

i) A list of relevant CIGRE references is given in the bibliography.

POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES ABOVE 30 kV (U_m = 36 kV) UP TO 150 kV (U_m = 170 kV) – TEST METHODS AND REQUIREMENTS

1 Scope

This document specifies test methods and requirements for power cable systems, cables alone and accessories alone, for fixed installations and for rated voltages above 30 kV (U_m = 36 kV) up to and including 150 kV (U_m = 170 kV).

The requirements apply to single-core cables and to individually screened three-core cables and to their accessories for usual conditions of installation and operation, but not to special cables, such as submarine cables and their accessories, for which modifications to the standard tests or the setup of special test conditions can be necessary.

This document does not cover transition joints between cables with extruded insulation and paper insulated cables.

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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-3, *High-voltage test techniques – Part 3: Definitions and requirements for on-site testing*

IEC 60137, *Insulated bushings for alternating voltages above 1 000 V*

IEC 60228, *Conductors of insulated cables*

IEC 60229:2007, *Electric cables – Tests on extruded oversheaths with a special protective function*

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

IEC 60287-1-1:2006, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*

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 60332-1-3, *Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles*

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

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

IEC 60754-3, *Test on gases evolved during combustion of materials from cables – Part 3: Measurement of low level of halogen content by ion chromatography*

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

IEC 60811-202:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*
IEC 60811-202:2012/AMD1:2017

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

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

IEC 60811-409, *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 60811-501:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulation and sheathing compounds*
IEC 60811-501:2012/AMD1:2018

IEC 60811-502:2012, *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 60811-505, *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 60811-508:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulations and sheaths*
IEC 60811-508:2012/AMD1:2017

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 60811-605:2012, *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 60885-3, *Electrical test methods for electric cables – Part 3: Test methods for partial discharge measurements on lengths of extruded power cables*

IEC 61034-2:2005, *Measurement of smoke density of cables burning under defined conditions –Part 2: Test procedure and requirements*
IEC 61034-2:2005/AMD1:2013

IEC 61462:2007, *Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods, acceptance criteria and design recommendations*

IEC 62155, *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*

IEC 62271-209, *High-voltage switchgear and controlgear – Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV. Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable-terminations*

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