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INTERNATIONAL STANDARD

AMENDMENT 1

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(en)

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INTERNATIONAL
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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

AMENDMENT 1

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Amendment 1 to IEC 60840:2020 has been prepared by IEC technical committee 20: Electric cables.

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

Draft	Report on voting
20/2100/FDIS	20/2107/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 Amendment 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/publications/.

The committee has decided that the contents of this document 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- withdrawn,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.

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2 Normative references

Add the following new references:

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

3 Terms and definitions

3.2.4
prequalification test

Add **"PQ test"** *as a second preferred term.*

3.2.5
extension of prequalification test

Add **"EQ test"** *as a second preferred term.*

3.3.2
nominal electrical stress

In the existing Note 2 to entry, delete "Nominal".

3.3.8
joint with screen or metal sheath interruption

Replace the existing entry 3.3.8 with the following new entry 3.3.8:

3.3.8
maximum service pressure
MSP
highest difference between the maximum absolute internal pressure, when the equipment (of which a composite hollow insulator is a part) is carrying its rated normal current at maximum operational temperature and the normal outside pressure

Insert, between the existing entry 3.3.9 and entry 3.3.10 the following new entry 3.3.11:

3.3.11
joint with screen or metal sheath interruption
joint, where the metal screen/sheath and insulation screen of the cable are electrically interrupted

3.3.10
termination with sectionalizing insulation

Replace the existing entry 3.3.10 with the following new entry 3.3.10:

3.3.10
termination with an insulated screen
termination where the metal screen/sheath and insulation screen of the cable are electrically interrupted to the ground

5 Precautions against water penetration in cables

Replace the existing first paragraph with the following new paragraph:

When cable systems are installed in water or in the ground, in locations with a risk of water ingress or corrosion, a radial water impermeable barrier is recommended.

6 Cable characteristics

Replace the existing text of list item c), excluding the NOTE, with the following new text:

c) Fire performance: if ST_1, ST_2 or ST_{12} oversheath material is used (see 4.4 and Table 2), then the subclauses of 12.5.14.3, if any, to which compliance is claimed, shall be declared.

Add, in list item n), after "d_{ii} is the declared nominal inner diameter of the insulation, in mm;" the following new text:

U_0 is the value in item b) above in kV;

7 Accessories characteristics

7.2 Composite insulators for outdoor cable terminations

Replace Subclause 7.2, including its title, with the following new Subclause 7.2:

7.2 Insulators for outdoor cable terminations

Insulators for outdoor cable terminations shall comply with the requirements given in Table 10 for Level I or II maximum cantilever operating load in service (or MML in the case of composite insulators). Level I refers to a normal load and shall be generally applied, unless a purchaser specifies a heavy load of Level II. Alternatively, a different value of maximum cantilever operating load or MML may be agreed between the purchaser and manufacturer. These tests are not applicable for cable terminations which are not subjected to cantilever stresses during operation, e.g. flexible terminations.

7.3 Accessory characteristics to be declared

Integrate the introductory sentence as part of list item a) as follows:

a) The following characteristics shall be declared by the manufacturer: cables used for testing accessories shall be correctly identified as in Clause 6;

Add, before the first bullet point of list item e), the following two new bullet points:

- design pressure for the outside of the termination insulator (see IEC 62271-209);
- type of insulating gas to be used in the cable connection enclosure (SF6 or details of alternative gas type).

Add, at the end of the second bullet point of list item f), after "(MSP)", *the word* "value" *and add the following new list item g):*

g) additional requirements for ceramic outdoor termination insulators:
   - the maximum cantilever operating load in service;
   - for insulators which will be pressurized in service, the design pressure.

8 Test conditions

8.3 Waveform of lightning impulse test voltages

Replace the existing paragraph with the following new paragraph:

The waveforms of lightning impulse tests shall be as given in IEC 60230.

Add, at the end of the existing Subclause 8.5, the following new Subclause 8.6:

8.6 Tests on gas immersed terminations

Electrical tests on gas immersed terminations shall be carried out in a cable connection enclosure with the diameter specified in IEC 62271-209 for the relevant value of rated voltage. The gas pressure requirements for electrical type tests given in IEC 62271-209 shall also be complied with.

9 Routine tests on cables and accessories

9.4 Electrical test on oversheath of the cable

Replace the existing paragraph with the following new paragraph:

Subject to agreement between the purchaser and manufacturer, the cable oversheath shall be subjected to the electrical test specified in Clause 3 of IEC 60229:2007.

10 Sample tests on cables

10.5 Measurement of electrical resistance of conductor and metal screen

Replace the existing second paragraph with the following new paragraph and bullet points:

The DC resistance of the conductor or metal screen/sheath shall be corrected to a temperature of 20 °C and a 1 km length of cable in accordance with the formulae and factors given in IEC 60228:

- for a conductor or metal screen/sheath of copper or aluminium, using the temperature coefficients given in IEC 60228 or
- for a metal screen/sheath other than copper or aluminium, using the temperature coefficients given in IEC 60287-1-1.

10.7.2.3 Ring method

Replace the first two sentences of the first paragraph with the following new sentence:

The measurements shall be made with a micrometer having ball noses of radii of approximately 3 mm.

10.12 lightning impulse voltage test

*Replace the fifth paragraph beginning with "*The lightning impulse voltage…" *with the following two new paragraphs:*

The lightning impulse voltage shall be applied, according to the procedure given in IEC 60230, after the completion of the 2 h heating and while the conductor temperature is within the limits stated above.

The cable shall withstand, without failure, 10 positive and 10 negative voltage impulses of the appropriate value given in Table 4, column 8.

10.14 Additional tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath

Replace the existing title with the following new title:

10.14 Tests on components of cables with a longitudinally applied metal tape or foil bonded to the oversheath

12 Type tests on cable systems

12.1 General

Delete the existing NOTE 1 and replace the existing NOTE 2 with the following new NOTE:

NOTE Tests on terminations under environmental conditions such as precipitation and/or pollution are not specified in this document.

12.2 Range of type approval

Replace, in the first paragraph, "conditions of a) to f)" *with* "conditions of a) to g)".

Add, at the end of list item g), the following new NOTE:

NOTE Clause H.6 gives requirements for approval of a gas immersed termination with an alternative type of gas.

12.3 Summary of type tests

Replace the existing second paragraph with the following new paragraph:

The non-electrical tests on cable components and complete cable are listed in Table 5 to Table 11, indicating which tests are applicable to each insulation and oversheath compound. The tests under fire conditions, as listed in Table 11, are only required if the manufacturer wishes to claim compliance with these tests as a special feature of the design of the cable.

12.4.2 Tests and sequence of tests

Add, at the end of the paragraph in list item b) the following second sentence:

No bending test is required if a different sample is selected.

12.4.3 Bending test

Replace, after list item 4), the definition of the symbol D_s with the following new definition:

D_s is the nominal diameter of the metal screen layer, in mm.

12.4.6 Heating cycle voltage test

Add, at the end of the last paragraph, the following new sentence:

Guidance concerning interruption of the test and the determination of valid heating cycles is given in Annex K.

12.4.7 Lightning impulse voltage test followed by a power frequency voltage test

Replace the existing second paragraph with the following new paragraph:

The conductor temperature shall be maintained within the stated temperature limits for at least 2 h before the first lightning impulse voltage is applied. The temperature shall be maintained within the above limits until the test is completed.

Replace the third paragraph with the following two new paragraphs:

If, for practical reasons, the test temperature cannot be reached, additional thermal insulation may be applied.

The lightning impulse voltage shall be applied, according to the procedure given in IEC 60230, after the completion of the 2 h heating and, while the conductor temperature is within the limits stated above.

12.5.5.4 Mechanical tests

Replace "IEC 60811-401" *with* "IEC 60811-501:2012 and IEC 60811-501:2012/AMD1:2018".

12.5.8 Test on PVC oversheaths (ST_1, ST_2) and LSHF oversheaths (ST_{12}) at low temperature

*Replace, in the existing title, "*Test on…*" with "*Test for…*" as follows:*

12.5.8 Test for PVC oversheaths (ST_1, ST_2) and LSHF oversheaths (ST_{12}) at low temperature

12.5.12 Measurement of density of HDPE insulation

Replace, in the existing title, "…density of…*" with* "…density for…" *as follows:*

12.5.12 Measurement of density for HDPE insulation

12.5.13 Measurement of carbon black content of black PE oversheaths (ST_3 and ST_7)

Replace, in the existing title, "…content of…*" with "*…content for…*" as follows:*

12.5.13 Measurement of carbon black content for black PE oversheaths (ST_3 and ST_7)

12.5.14 Test under fire conditions

Replace the contents of Subclause 12.5.14 with the following new Subclause 12.5.14:

12.5.14 Test under fire conditions

12.5.14.1 General

The tests in 12.5.14.2 shall be carried out on ST_{12} (LSHF) oversheath material.

The tests in 12.5.14.3 shall be carried out in accordance with the fire performance claimed for the cable, see Clause 6, item c).

12.5.14.2 Tests on gases evolved during combustion of ST_{12} (LSHF) oversheath

12.5.14.2.1 Determination of acidity (by pH measurement) and conductivity of gases evolved during combustion

The test according to IEC 60754-2 shall be carried out on the oversheath of the cable.

The results shall comply with the requirements given in Table 11.

12.5.14.2.2 Measurement of halogen content of gases evolved during combustion

The value for the oversheath, H_i, of the individual halogen content for each of the four halogens F, Cl, Br, and I, shall be determined by carrying out the test according to IEC 60754-3.

The values for each of the four individual halogens, H_i, and the sum of the values for the oversheath for the four halogens, i.e. $\sum H_i$, shall comply with the requirements given in Table 11.

12.5.14.3 Fire performance tests for the cable

12.5.14.3.1 Vertical flame propagation test for single cable

The test under fire conditions in accordance with IEC 60332-1-2 shall be carried out on a sample of completed cable. During the test, the determination of flaming droplets and particles shall be carried out in accordance with IEC 60332-1-3.

The results for IEC 60332-1-2 shall comply with the requirements given in Table 11 and the filter paper (IEC 60332-1-3) shall not ignite during the test duration.

If a failure to meet the requirements of either standard is recorded, two more tests shall be carried out. If both tests result in passes, the cable shall be deemed to have passed the test.

12.5.14.3.2 Test for vertical flame spread of vertically-mounted cables

The test for vertical flame spread of vertically-mounted cables shall be carried out in accordance with IEC 60332-3-24, on samples of completed cable. The results shall comply with the requirements given in Table 11.

NOTE Higher performance to meet the requirements of IEC 60332-3-22 or IEC 60332-3-23 can be agreed between the purchaser and manufacturer. The fire performance level achieved depends on cable design as well as material performance.

12.5.14.3.3 Measurement of smoke density of cables burning under defined conditions

The test for measurement of smoke density of cables burning under defined conditions shall be carried out in accordance with IEC 61034-2 on a sample of completed cable.

The results shall comply with the requirements given in Table 11.

12.5.14.3.4 Determination of acidity (by pH measurement) and conductivity of gases evolved during combustion of the non-metallic materials in the cable

The test according to IEC 60754-2 shall be carried out on the non-metallic components of the cable. Non-metallic components with a mass less than or equal to 1 % of the total non-metallic mass need not be tested.

The weighted values of pH and conductivity of the non-metallic components of the cable shall be calculated according to IEC 60754-2 and shall comply with the requirements given in Table 11.

12.5.14.3.5 Measurement of halogen content of gases evolved during combustion of the non-metallic materials in the cable

The weighted value for the cable, $H_i^{'}$, for the four halogens F, Cl, Br, and I, shall be determined by carrying out the test according to IEC 60754-3 either:

- individually on each non-metallic component of the cable, and calculating the weighted value for the cable, for each halogen, as described in Annex L,
- or on a sample representative of the cable construction prepared as described in Annex L, in which case the result for each halogen shall be taken as the weighted value for the cable.

Non-metallic components with a mass less than or equal to 1 % of the total non-metallic mass need not be tested.

The weighted value for the cable, $H_i^{'}$, for each of the four individual halogens and the sum of the weighted values for the non-metallic components of the cable for the four halogens, i.e. $\sum H_i^{'}$, shall comply with the requirements given in Table 11.

12.5.16 Tests of components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath

Replace the existing list item b) with the following new item b):

b) adhesion strength of the laminated metal tape or foil (see Clause G.2);

Add, after list item b), the following new item c):

c) peel strength of the laminated metal tape or foil (see Clause G.2).

12.5.17.1 Procedure

Replace the paragraph with the following new paragraph:

The shrinkage test shall be carried out on insulations of PE, HDPE and XLPE using the sampling and test procedure described in IEC 60811-502:2012, except in the case of 3 core cables where each of the 3 cores shall be tested to IEC 60811-502:2012 as if they were individual cables using the conditions specified in Table 8.

12.5.17.2 Requirements

Add, at the end of the existing sentence, the following new sentence:

In the case of 3 core cables the results for each core shall comply.

13 Prequalification test of the cable system

13.1 General and range of prequalification test approval

Replace the contents of Subclause 13.1 with the following:

When a PQ test has been successfully performed on a cable system, it qualifies the manufacturer as a supplier of cable systems of the same family with the same or lower voltage ratings, as long as the calculated nominal electrical stresses at the cable insulation screen are equal to or lower than for the tested cable system.

The PQ test shall be performed on cable systems where the calculated nominal electrical stresses at the conductor screen are higher than 8,0 kV/mm and/or at the insulation screen higher than 4,0 kV/mm. The PQ test shall be performed except:

– if cable systems with the same construction and accessories of the same family have been prequalified for an equal or higher rated voltage;
– or if the manufacturer can demonstrate good service experience with cable systems with equal or higher calculated electrical stresses on the conductor and insulation screens, in the main insulation part(s) and in boundaries of the accessories and of accessories of the same family;
– or if the manufacturer has fulfilled the requirements of an equivalent long-term test on a cable system at an equal or higher voltage rating with the same construction and accessories of the same family, following a national or customer specification.

When a prequalified cable system is changed by exchanging a cable and/or accessory with another one that is already prequalified in another cable system with the same or higher calculated nominal electrical stresses at the insulation screen of the subjected system, the current prequalification shall be extended with this cable and/or accessory when the requirements of 13.3 are all met.

When a prequalified cable system is changed by using another cable and/or accessory that is not part of a prequalified cable system, or is already prequalified in another cable system with lower calculated nominal electrical stresses at the insulation screen of the subjected system, the PQ test on this new complete cable system shall be performed by meeting all the requirements of 13.2.

The PQ test need only be carried out once unless there is substantial change in the cable system with respect to material, manufacturing process, design or design electrical stress levels. A substantial change is defined as that which might adversely affect the performance of the cable system. The manufacturer should provide a detailed case, including test evidence, if modifications are introduced, which are claimed not to constitute a substantial change.

It is recommended to carry out a PQ test using a cable of a large conductor cross-section in order to cover thermo-mechanical aspects.

A list of PQ tests as well as EQ tests is given in Annex C.

A PQ or EQ test certificate signed by the representative of a competent witnessing body, or a report by the manufacturer giving the test results and signed by the appropriate qualified officer, or a PQ or EQ test certificate issued by an independent test laboratory shall be acceptable as evidence of prequalification testing. Such a certificate or report shall include details of the indoor test arrangement or outdoor installation and shall specify details of laying conditions and how the cable system was installed.

For a more detailed understanding of the need for a PQ or EQ test, reference should be made to CIGRE TB 303.

13.2.5 Lightning impulse voltage test

Add, at the end of the first paragraph, the following new sentence:

The temperature shall be maintained within the above limits while the lightning impulse voltages are applied.

*Replace, in the second paragraph, "*impulse voltage*" with "*lightning impulse voltage".

13.3.2.1 General

Replace the second paragraph with the following two new paragraphs:

The minimum total cable length shall be 20 m, not including that inside accessories. The minimum length of cable between accessories shall be 5 m.

A bending test according to 12.4.3 shall be carried out on the cable, before the installation of the accessories.

Delete the existing fifth paragraph beginning with "If the cable is part…".

13.3.2.3 Sequence of the electrical part of the extension of prequalification tests

Replace the existing list items a) and b) with the following new items a) and b):

a) installation of the accessories that shall be carried out by the cable or accessory manufacturer or their representative;

b) partial discharge test at ambient temperature (see 12.4.4) to check the installation and the quality of the installed accessories;

13.3.2.4 Heating cycle test without voltage

Add, at the end of the last paragraph, the following two new paragraphs:

Heating cycles with a conductor temperature higher than 5 K above the maximum conductor temperature in normal operation are considered valid.

Interruption of the test is allowed, provided that 60 complete heating cycles in total are completed. Guidance concerning interruption of the test and the determination of valid heating cycles is given in Annex K.

14 Type tests on cables

14.3 Summary of tests

Replace the second paragraph with the following new paragraph:

The non-electrical tests on cable components and complete cable are listed in Table 5 and Table 11, indicating which tests are applicable to each insulation and oversheath compound. The tests under fire conditions, as listed in Table 11, are only required if the manufacturer wishes to claim compliance with these tests as a special feature of the design of the cable.

16 Electrical tests after installation

Replace the existing title of Clause 16 with the following new title:

16 Electrical tests after installation (on-site tests)

16.1 General

Add, at the end of the last paragraph of 16.1, the following new paragraph:

The tests carried out shall be in accordance with IEC 60060-3.

16.2 DC voltage test of the oversheath

Replace the two paragraphs with the following two new paragraphs:

The electrical test after installation shall be carried out on the oversheath according to IEC 60229:2007.

For the test to be effective, it is necessary that the ground makes good contact with all of the outer surface of the oversheath. The test cannot be carried out unless the oversheath has an outer electrode e.g. moist backfill or a conductive layer.

16.3 AC voltage test of the insulation

Replace the title of Subclause 16.3 and the first three paragraphs with the following:

16.3 Tests using AC voltage

16.3.1 AC voltage test of the insulation

The AC test voltage to be applied shall be subject to agreement between the purchaser and the manufacturer.

The waveform shall be substantially sinusoidal and the frequency shall be between 20 Hz and 300 Hz. In particular cases, the minimum frequency can be reduced to 10 Hz subject to agreement between the purchaser and the manufacturer.

A voltage according to Table 12, column 4 shall be applied for 1 h, alternatively a voltage of U_0 can be applied for 24 h.

For installations which have been in use, lower voltages than given in Table 12 and/or shorter durations can be used. Values should be negotiated, taking into account the age, environment, history of breakdowns and the purpose of carrying out the test.

16.3.2 Partial discharge test

A partial discharge (PD) test under AC voltage is recommended and can be carried out by agreement between the purchaser and the manufacturer. Distributed PD measurements can be carried out along the cable route. Typical pass criteria for such measurements are no detectable PD from the cable system at 1,5 U_0, or at the test voltage, if lower. When applicable, the test procedure and pass criteria should be agreed. The PD test can be carried out during the AC voltage test of the insulation (at the voltage used for that test) or as a separate test. PD tests shall not be considered to replace the AC voltage test of the insulation.

Table 4 – Test voltages

Delete the last column 10 and footnote "b" and renumber footnote "c" as footnote "b".

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

Replace the existing Table 5 with the following new Table 5:

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

Designation of compound (see 4.2 and 4.4)	Insulation				Oversheath				
	PE	HDPE	EPR	XLPE	ST_1	ST_2	ST_3	ST_7	ST_{12}
Checks on construction *Water penetration test* [a]	Applicable irrespective of insulation and oversheathing compounds								
Mechanical properties (Tensile strength and elongation at break)									
a) Without ageing	x	x	x	x	x	x	x	x	x
b) After ageing in air oven	x	x	x	x	x	x	x	x	x
c) After ageing of the complete cable (compatibility test)	x	x	x	x	x	x	x	x	x

Designation of compound (see 4.2 and 4.4)	Insulation				Oversheath				
	PE	HDPE	EPR	XLPE	ST_1	ST_2	ST_3	ST_7	ST_{12}
Pressure test at high temperature	–	–	–	–	x	x	–	x	x
Behaviour at low temperature									
a) Cold elongation test	–	–	–	–	x	x	–	–	x
b) Cold impact test	–	–	–	–	x	x	–	–	x
Loss of mass in air oven	–	–	–	–	–	x	–	–	–
Heat shock test	–	–	–	–	x	x	–	–	–
Ozone resistance test	–	–	x	–	–	–	–	–	–
Hot set test	–	–	x	x	–	–	–	–	–
Measurement of density	–	x	–	–	–	–	–	–	–
Carbon black content[b]	–	–	–	–	–	–	x	x	–
Shrinkage test	x	x	–	x	–	–	x	x	x
Determination of hardness	–	–	–	–	–	–	–	–	–
Determination of elastic modulus	–	–	–	–	–	–	–	–	–
pH value (12.5.14.5)	–	–	–	–	–	–	–	–	x
Conductivity test (12.5.14.5)	–	–	–	–	–	–	–	–	x
Halogen content (12.5.14.6)	–	–	–	–	–	–	–	–	x

Key

x: the test is to be applied

–: the test is not to be applied

[a] To be applied to those designs of cable where the manufacturer claims that barriers to longitudinal water penetration have been included.

[b] For black oversheaths only.

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

Replace the existing Table 9 with the following new Table 9:

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

Designation of compound (see 4.4)	**Unit**	**ST_1**	**ST_2**	**ST_{12}**
Loss of mass in air oven (IEC 60811-409)				
Treatment: temperature	°C	–	100	–
tolerance	K	–	±2	–
duration	h	–	168	–
Maximum permissible loss of mass	mg/cm^2	–	1,5	–
Behaviour at low temperature [a]				
Tests to be carried out without previous ageing:				
a) Cold elongation test on dumb-bells (IEC 60811-505)				
Test temperature	°C	−15	−15	−15
Tolerance	K	±2	±2	±2
Requirement	%	≥ 20	≥ 20	≥ 20
b) Cold impact test (IEC 60811-506)				
Test temperature	°C	−15	−15	−15
Tolerance	K	±2	±2	±2
Requirement	–	no cracks	no cracks	no cracks
Heat shock test (IEC 60811-509)				
Treatment: test temperature	°C	150	150	–
tolerance	K	±3	±3	–
test duration	h	1	1	–
Requirement		no cracks	no cracks	–

[a] Due to climatic conditions, national standards may require the use of a lower or higher test temperatures.

Insert, between Table 9 and Table 10, the following new Table 11:

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

Designation of compound (see 4.4)		Unit	ST_1	ST_2	ST_{12}
Tests on ST_{12} (LSHF) oversheath material					
pH value and conductivity tests (12.5.14.2.1) (IEC 60754-2)					
	pH	–	–	–	≥ 4,3
	Conductivity	µS/mm	–	–	≤ 10
Halogen content of gases (12.5.14.2.2) (IEC 60754-3)					
Value for each of the 4 individual halogens (F, Cl, Br, I)	H_i	mg/g	–	–	≤ 2
Sum of values for the 4 individual halogens (F, Cl, Br, I)	$\sum H_i$	mg/g	–	–	≤ 5
Tests for cable					
Vertical flame propagation test for single cable (12.5.14.3.1) (IEC 60332-1-2)					
Distance between the lower edge of the top support and the onset of charring		mm	> 50	> 50	> 50
The lower extent of charring below the lower edge of the top support		mm	≤ 540	≤ 540	≤ 540
Test for vertical flame spread of vertically-mounted cables (12.5.14.3.2) (IEC 60332-3-24)					
Upper limit of char above bottom edge of burner		m	–	–	≤ 2,5
Smoke density test of cables (12.5.14.3.3) (IEC 61034-2)					
Normalized transmittance	$(I_t/I_0)_{norm}$	%	–	–	≥ 60
pH value and conductivity tests (12.5.14.3.4) (IEC 60754-2)					
Weighted value for the non-metallic materials in the cable	pH	–	–	–	≥ 4,3
	Conductivity	µS/mm	–	–	≤ 10
Halogen content of gases evolved during combustion (12.5.14.3.5) (IEC 60754-3)					
Weighted values for non-metallic materials in the cable	Value for each of the 4 individual halogens (F, Cl, Br, I) H_i'	mg/g	–	–	≤ 2
	Sum of the values for the 4 individual halogens (F, Cl, Br, I) $\sum H_i'$	mg/g	–	–	≤ 5

Table 10 – Maximum mechanical load for composite insulators for outdoor terminations

Replace the existing Table 10, including its title, with the following new Table 10:

Table 10 – Cantilever operating load for insulators for outdoor terminations

Highest voltage for equipment U_m kV	Rated current A			
	< 800		1 000 to 1 600	
	Maximum cantilever operating load in service and for which the insulator is designed (= MML for composite insulators)			
	N			
	Termination installed < 30° from the vertical			
	I	II	I	II
52	500	800	625	800
72,5	500	1 000	625	1 000
123 and 145	625	1 575	800	1 575
170	625	2 000	800	2 000

Key

Level I = normal load, Level II = heavy load

For outdoor terminations operating at an angle > 30° to the vertical, the effect of termination self-load should be considered when selecting test load and procedure. The values given above correspond to vertical terminations that are to be tested in a vertical position. If a tilted or horizontal termination is to be tested vertically, then an equivalent force should be added to achieve the bending moment at the flange, caused by the weight of the termination in its operating position. If a vertical termination is to be tested horizontally, then the test load can be reduced in the same manner.

NOTE This table is derived from IEC 60137.

Add, at the end of the existing Table 10, the following new Table 12:

Table 12 – Test voltages for AC voltage test after installation

1	2	3	4	5
Rated voltage	**Highest voltage for equipment**	**Value of U_0 for determination of test voltages**	**Voltage test after installation of 16.3.1 [a]**	
U kV	U_m kV	U_0 kV	20 (10) Hz to 300 Hz kV	Multiplier - × U_0
45 to 47	52	26	52	2,0
60 to 69	72,5	36	72	2,0
110 to 115	123	64	128	2,0
132 to 138	145	76	132	1,7
150 to 161	170	87	150	1,7

[a] If necessary, these test voltages shall be adjusted as stated in 16.3.1.

Annex C

Table C.3 – Extension of 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

Replace the existing Table C.3, including its title, with the following new Table C.3:

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

Item	Test	Subclauses
a	General and range of prequalification test approval	13.1
b	Tests for the extension of the prequalification of a cable system	13.3
c	Electrical part of the extension of prequalification tests on complete cable system	13.3.2
d	Test voltage values	13.3.2.2
e	Bending test without partial discharge test	12.4.3
f	Partial discharge test at ambient temperature after installation of the accessories that are part of the test	12.4.4
g	Heating cycle test without voltage	13.3.2.4
h	Tan δ measurement	12.4.5
i	Heating cycle voltage test	12.4.6
j	Partial discharge test at ambient and high temperatures (after final cycle in item i above or after lightning impulse voltage test in item k below)	12.4.4
k	Lightning impulse voltage test followed by power frequency voltage test	12.4.7
l	Partial discharge test at high temperature (if not carried out after item i above)	12.4.4
m	Additional tests for accessories	Annex H
n	Examination	12.4.8
o	Resistivity of semi-conducting screens	12.4.9
p	Non-electrical type tests on cable components and on completed cable	12.5

Annex E

E.1 Test piece

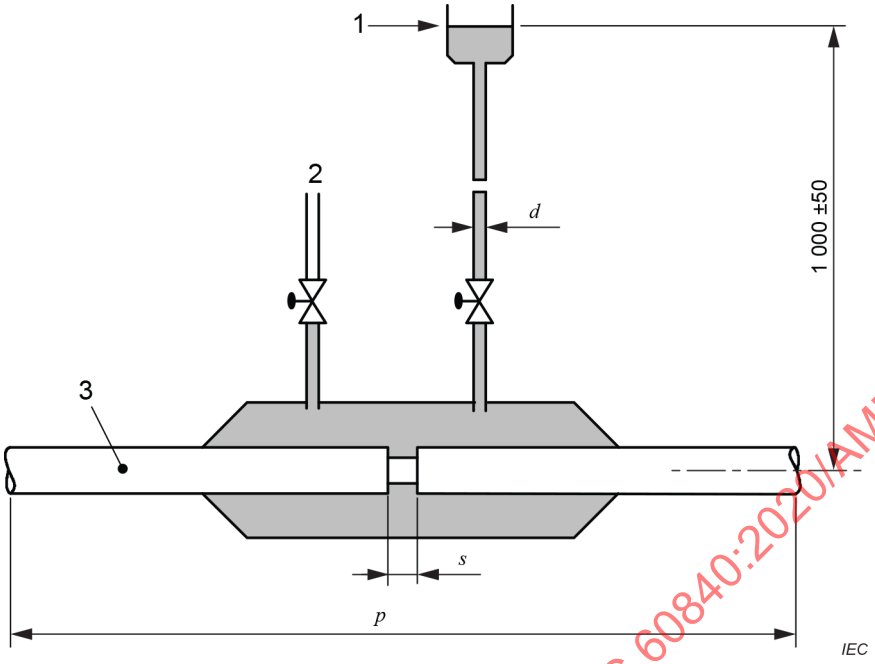
*Replace, in the first sentence of the second paragraph, "*6 m*" with "*(6 000 ± 50) mm".

E.2 Test

*Replace, in the fifth paragraph, "*1 m*" with "*(1,0 ± 0,05) m*".*

Replace the existing Figure E.1 with the following new Figure E.1:

Dimensions in mm



Key

1	water header tank	*d*	Ø10 mm minimum (inner)
2	vent	*s*	50 mm approximately
3	cable	*p*	length = (8 000 ± 50) mm

Figure E.1 – Schematic diagram of apparatus for water penetration test

Annex F

F.1 Test piece

Replace, in the first paragraph, "3 m" *with* "(3 000 ± 50) mm".

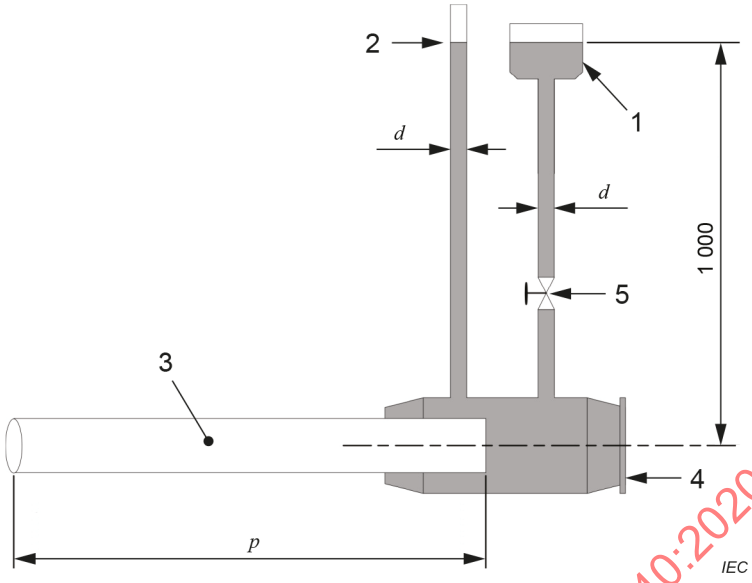
Replace, in the second sentence of the third paragraph, "1 m" *with* "(1 000 ± 50) mm".

F.2 Test

Replace, in the first paragraph, "1 m" *with* "(1 000 ± 50) mm".

Replace the existing Figure F.1 with the following new Figure F.1:

Dimensions in mm



Key

1 water header tank
2 air vent
3 test piece
4 chamber
5 full bore valve (optional)
d internal Ø = 10 mm minimum
p length = (4 000 ± 50) mm

Figure F.1 – Schematic diagram of apparatus for water penetration test in the conductor

Annex H

Replace the existing Annex H with the following new Annex H:

Annex H
(normative)

Additional tests for accessories

H.1 General

Annex H specifies the procedure for additional tests, which are either type tests or extension of qualification tests for accessories for:

– joints with or without screen interruption;
– accessories for cable screen interruption and/or earth connection;
– terminations with an insulated screen;
– insulators for outdoor terminations;
– gas immersed terminations, when changing the insulating gas in the cable connection enclosure.

Accessories specified for installation in air only can be tested without the water immersion test, subject to agreement between the purchaser and manufacturer. The risk of presence of water, for example in terms of tunnel installation or any other risk of temporary exposure of joints or accessories to water, should be considered in this case.

Accessories tested with the water immersion test are compliant when used for installation in air as well as in other situations. Accessories tested without the water immersion test are not compliant when used for buried installation or in an environment with the risk of exposure to water.

The manufacturer of the accessory shall provide a drawing in which all relevant features tested under this annex are clearly defined and identified.

Table H.1 lists the test procedures for different types of accessories.

Table H.1 – Test sequence

Test sequence	Joints without screen or metal sheath interruption and cable accessories without a screen or metal sheath/screen interruption (e.g. earth connection)	Joints with screen or metal sheath interruption and cable accessories with a screen or metal sheath/screen interruption (e.g. earth connection and/or cross bonding applications)	Terminations with an insulated screen	Insulators for outdoor terminations	Change of insulating gas for gas immersed termination
	Clause H.3	Clause H.3	Clause H.4	Subclause H.4.4	Clause H.6
Subjected to 20 thermal cycles with or without voltage	X	X	X[b]	–	–
Water immersion conditioning (20 thermal cycles)	X[a]	X[a]	–	–	–
DC voltage withstand test screen to earth	X	X	X	–	–
DC voltage withstand test screen to screen	–	X	–	–	–
Lightning impulse voltage withstand test screen to earth	X	X	X	–	–
Lightning impulse voltage withstand test screen to screen	–	X	–	–	–
Internal pressure test	–	–	–	X	–
Cantilever load test (ceramic) or bending test (composite)	–	–	–	X	–
Examination	X	X	X	–	–
Electrical tests	–	–	–	–	X
Leak rate test	–	–	–	–	X

[a] Not applicable to accessories for installation in air, tested without water immersion.

[b] Not applicable if the sheath sectionalizing insulation is external to the main body of the accessory, see H.4.1.

H.2 Range of approval

H.2.1 Range of approval for joints without screen or metal sheath interruption

When the test sequence according to this annex has been successfully performed for a joint design without screen interruption, the type approval shall be considered as valid for all joints without screen interruption for the same conductor size or smaller, embodying the same basic design principles and the same materials tested at equal or lower test voltages.

Where approval is required for joint outer protection embodying entries for items such as bonding leads, the outer protection tested shall include these design features.

A successful test on the joint outer protection with embodying entries will give approval to such outer protection for a similar joint without embodying entries, but not the converse.

H.2.2 Range of approval for joints with screen or metal sheath interruption

When the test sequence according to this annex has been successfully performed for a joint design with screen interruption, the type approval shall be considered as valid for all joints with or without screen interruption for the same conductor size or smaller, embodying the same basic design principles and the same materials tested at an equal or lower voltage group.

Where approval is required for joint outer protection embodying entries for items such as bonding leads, the outer protection tested shall include these design features.

A successful test on the joint outer protection with embodying entries will give approval to such outer protection for a similar joint without embodying entries, but not the converse.

H.2.3 Range of approval for accessories for cable screen interruption and/or earth connection

When the test sequence according to this annex has been successfully performed on a cable with screen or metal sheath interruption, the type approval shall be considered as valid for all cables with screen or metal sheath interruption offered by the same manufacturer, embodying the same basic design principles, at an equal or lower voltage group.

H.2.4 Range of approval for terminations with an insulated screen

When the test sequence according to this annex has been successfully performed for terminations with an insulated screen, the type approval shall be considered as valid for all terminations without an insulated screen, offered by the same manufacturer, embodying the same basic design principles, at an equal or lower voltage group.

H.3 Tests of joints with or without screen or metal sheath interruption and accessories for cable screen interruption and/or earth connection

H.3.1 Conditioning of sample for test

The test of joints, cables with a metal sheath interruption and accessories for cable screen interruption and/or earth connection, shall be applied to an accessory which has passed the heating cycle voltage test (see 12.4.6) or to a separate accessory which has undergone at least 20 thermal cycles according to 12.4.6 but without voltage applied.

If the accessory is not to be subjected to wet conditions in service (i.e. not directly buried in earth or not intermittently or continuously immersed in water), the test in H.3.2 can be omitted.

H.3.2 Water immersion test

The assembly to be approved shall be immersed in water to a depth of not less than 1,0 m at the highest point of the outer protection. Where desired, this can be achieved by using a header tank connected to a sealed-off vessel containing the test assembly.

Additional voltage tests according to H.3.3 can be carried out before commencing the heating/cooling cycles, at the discretion of the manufacturer.

A total of 20 heating/cooling cycles shall be applied by raising the water temperature to within 15 K to 20 K below the maximum temperature of the cable conductor in normal operation. In each cycle, the water shall be raised to the specified temperature, maintained at that level for at least 5 h and then be permitted to cool to within 10 K above the ambient temperature. The test temperature can be achieved by mixing the water with water of higher or lower temperature. The minimum duration of each cycle of heating and cooling shall be 12 h and the duration for raising the water temperature to the specified temperature shall be as much as possible the same as the duration for cooling the water to within 30 °C or 10 K above the ambient temperature, whichever is the higher.

H.3.3 Electrical tests

H.3.3.1 General

For accessories subjected to the water immersion test, voltage tests shall be carried out on completion of the heating cycles in water, with the test assembly still immersed. If it is not practicable to carry out the electrical tests whilst the assembly is still immersed in water, the assembly can be removed from the water and the voltage tests carried out with a minimum of delay. In this case, earthing of the test object can be achieved by wrapping with a wet fabric, or by using a conductive coating applied over the entire exterior surface of the test assembly.

For accessories without a water immersion, test earthing of the test object can be achieved by wrapping with a conductive tape or mesh, or using a conductive coating applied over the entire exterior surface of the test assembly.

All accessories shall be subjected to the tests in H.3.3.2 and H.3.3.4. In addition, accessories with a screen or metal sheath interruption shall also be subjected to the tests in H.3.3.3 and H.3.3.5. In both cases the tests shall be carried out in the order given below. All tests in this annex shall be carried out at ambient temperature if not specified otherwise.

No breakdown of the test object shall occur during any of the electrical withstand tests. Failure or flashover of a termination of the cable shall not be considered a failure of the test object.

H.3.3.2 DC voltage withstand test between screen and earth

A test voltage of 25 kV DC shall be applied for 1 min between the metal screen or sheath and the earthed exterior of the test object.

H.3.3.3 DC voltage withstand test between screen and screen

A test voltage of 25 kV DC shall be applied for 1 min between both sides of the metal screen or sheath interruption of the test object.

H.3.3.4 Lightning impulse voltage withstand test between screen and earth

A test voltage in accordance with Table H.2 shall be applied between the metal screens/sheaths and the exterior of the assembly.

The testing procedure shall be performed in accordance with IEC 60230.

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

Highest voltage for equipment U_m [a]	Lightning impulse level	
	Each part to earth	
	Bonding leads ≤ 3 m [c]	Bonding leads > 3 m and ≤ 10 m [b]
kV	kV	kV
≤ 72,5	30	30
> 72.5	30	37,5

[a] See Table 4, column 2.

[b] If sheath voltage limiters are placed adjacent to the joint or cable, the voltages for bonding leads ≤ 3 m are used.

[c] Including accessories with sheath voltage limiters fitted directly – cable side to earth only.

H.3.3.5 Lightning impulse voltage withstand test between screen and screen

Before the lightning impulse test between the metal screens/sheaths, the assembly shall be removed from the water, if applicable.

To test between parts, a test voltage in accordance with Table H.3 shall be applied.

The testing procedure shall be performed in accordance with IEC 60230.

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

Highest voltage for equipment U_m [a]	Lightning impulse level	
	Between parts [c]	
	Bonding leads ≤ 3 m	Bonding leads > 3 m and ≤ 10 m [b]
kV	kV	kV
≤ 72,5	60	60
> 72.5	60	75

[a] See Table 4, column 2.

[b] If sheath voltage limiters are placed adjacent to the joint or cable, the voltages for bonding leads ≤ 3 m are used.

[c] Between parts is used here synonymously for tests between screen to screen of joints with screen or metal sheath interruption or accessories for cable screen interruption and/or earth connection.

H.3.4 Examination

The examination of the accessories shall be done as stated in 12.4.8.1 and in addition for accessories subjected to the water immersion test:

– the accessory shall be examined with respect to the defined and clearly identified water-protection barriers (see Clause H.1);

– outer protection boxes filled with removable compounds shall be regarded as satisfactory if there is no visible evidence of either internal voids or internal displacement of compound by water ingress, or of compound loss via the various seals or box walls;

– for outer protections employing alternative designs and materials, there shall be no evidence of water ingress or internal corrosion behind the defined water-protection barriers.

H.4 Tests of terminations with an insulated screen

H.4.1 Conditioning of sample for test

The test of terminations with an insulated screen shall be applied to an accessory which has passed the heating cycle voltage test (see 12.4.6) or to a separate accessory which has undergone at least 20 thermal cycles according to 12.4.6 but without voltage applied. This requirement can be omitted if the screen insulation is external to the main body of the accessory, for example in the case of support insulators.

H.4.2 DC voltage withstand test between screen and earth

A test voltage of 25 kV DC shall be applied for 1 min between the screen and earth.

H.4.3 Lightning impulse voltage withstand test between screen and earth

A test voltage in accordance with Table H.4 shall be applied between the screen and earth.

The testing procedure shall be performed in accordance with IEC 60230.

Table H.4 – Lightning impulse voltage withstand tests between screen and earth of terminations with an insulated screen

Highest voltage for equipment U_m [a] kV	Lightning impulse level Sheath sectionalizing insulation of terminations kV
≤ 72,5	30
> 72,5	37,5

[a] See Table 4, column 2.

H.4.4 Examination

The examination of the accessories shall be done as stated in 12.4.8.1.

H.5 Tests for insulators for outdoor terminations

H.5.1 Tests for ceramic insulators

H.5.1.1 General

One insulator of each type shall be subjected to the tests given in H.5.1.2 and H.5.1.3. Alternatively, a certificate or test report can be provided, as acceptable evidence of testing as specified in 12.2.

H.5.1.2 Internal pressure test

For insulators which will be pressurized in service, the type test pressure test shall be carried out according to IEC 62155.

The requirements of IEC 62155 shall be met.