IEC 61442

Edition 3.0 2023-10
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Test methods for accessories for power cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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TEST METHODS FOR ACCESSORIES FOR POWER CABLES WITH RATED VOLTAGES FROM 6 kV (U_m = 7,2 kV) UP TO 30 kV (U_m = 36 kV)

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61442:2005. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61442 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This third edition cancels and replaces the second edition published in 2005. This edition constitutes a technical revision.

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

a) 4.6 – the option to start tests immediately has been included;
b) 4.11 – methods for testing on belted cables have been included;
c) 5.3.2 and 10.3 – details of insulation resistance testing has been added;
d) 8.2 – pre-stress with slightly increased test voltage before applying the partial discharge test has been included;
e) 11.2 – testing of accessories with external earthing devices has been included;
f) 11.2 – short-circuit duration and maximum kA levels have been added;
g) 11.2 – temperature measurement is not required if the time between short-circuits > 1 h.

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

Draft	Report on voting
20/2108/FDIS	20/2132/RVD

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

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/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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TEST METHODS FOR ACCESSORIES FOR POWER CABLES WITH RATED VOLTAGES FROM 6 kV (U_m = 7,2 kV) UP TO 30 kV (U_m = 36 kV)

1 Scope

This document specifies the test methods applicable for type testing accessories for power cables with rated voltages from 3,6/6 (7,2) kV up to 18/30 (36) kV. The test methods specified in this document apply to accessories for extruded and paper insulated cables according to IEC 60502-2 and IEC 60055-1 respectively.

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 60055-1: *Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV (with copper or aluminium conductors and excluding gas-pressure and oil-filled cables) – Part 1: Tests on cables and their accessories*~~

IEC 60060-1:~~1989~~2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60230:~~1966~~2018, *Impulse tests on cables and their accessories*
IEC 60230:2018/AMD1:2021

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*
IEC 60270:2000/AMD1:2015

~~IEC 60502-2:2005, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*~~

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

IEC 60811-401:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*
IEC 60811-401:2012/AMD1:2017

IEC 60885-2:1987[1], *Electrical test methods for electric cables – Part 2: partial discharge tests*

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

~~IEC 60986:2000, *Short-circuit temperature limits of electric cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*~~

[1] Withdrawn.

~~IEC 61238-1:2003, *Compression and mechanical connectors for power cables for rated voltages up to 30 kV (U_m = 36 kV) – Part 1: Test methods and requirements*~~

IEC 61238-1-3:2018, *Compression and mechanical connectors for power cables – Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) tested on non-insulated conductors*

IEC 60949:1988, *Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects*
IEC 60949:1988/AMD1:2008

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Test installations and conditions

4.1 The test methods described in this document are intended to be used for type tests.

4.2 The test arrangements and the number of test samples are given in the relevant standard.

4.3 The test conditions are specified in Clause 5 to Clause 21. When they are not, they shall be as specified in the relevant standards.

4.4 The testing parameters and the requirements are given in the relevant standard, unless otherwise stated.

4.5 For transition joints (either extruded insulation to extruded insulation or extruded insulation to paper insulation), the testing parameters (voltage and conductor temperature) are those of the lower rated cable.

4.6 The tests ~~shall~~ can be started ~~not less than 24 h~~ immediately after installation of accessories on the cable test loops, unless otherwise specified by the manufacturer. The time interval between installation of the accessories and the start of the tests shall be recorded in the test report.

4.7 Cable screens, and armour if any, shall be bonded and earthed at one end only to prevent circulating currents.

4.8 All parts of an accessory which are normally earthed shall be connected to the cable screen. Any supporting metalwork shall also be earthed.

4.9 The ambient temperature shall be (20 ± 15) °C.

4.10 Tap water shall be used for all tests in water.

4.11 Tests on belted cables:

When conducting AC voltage tests and heating cycle voltage tests, a three-phase test voltage and current system shall be used.

When conducting DC voltage tests and the impulse tests, the test voltage shall be applied to one cable conductor and the other two cable conductors and the screen shall be earthed. All cable conductors shall be tested separately.

5 AC voltage tests

5.1 Dry test for all accessories

5.1.1 Installation

The set(s) of accessories shall be erected with all associated metalwork and fittings. The accessories shall be clean and dry before applying the test voltage.

5.1.2 Method

The test shall be made at ambient temperature, and the procedure for voltage application shall be as specified in IEC 60060-1:2010, Clause 6, unless otherwise specified.

5.2 Wet test for outdoor terminations

5.2.1 Installation

The terminations shall be erected in a vertical position, unless they are to be specifically installed in another orientation, with the relative spacing as under service conditions and according to the manufacturer's instructions.

5.2.2 Method

The wet test method is as described in IEC 60060-1:2010, 4.4, and shall be carried out at ambient temperature, unless otherwise specified.

5.3 Test in water for stop ends

5.3.1 Installation

The stop ends shall be installed in a water tank of such dimensions as to have a height of water of 1,00 $^{+0,1}_{0}$ m over their top surface, unless otherwise specified. The water shall be at ambient temperature.

5.3.2 Method

The procedure for voltage application shall be as specified in IEC 60060-1:2010, 6.2, unless otherwise specified.

After the AC voltage withstand, the insulation resistance shall be measured between the screen and water. The DC test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case, not less than 1 min and not more than 5 min.

6 DC voltage tests

6.1 Installation

The set(s) of accessories shall be erected with all associated metalwork and fittings. The accessories shall be clean and dry before applying the test voltage.

6.2 Method

A voltage of negative polarity shall be applied to the cable conductor.

The test shall be made at ambient temperature and the procedure for voltage application shall be as specified in IEC 60060-1:2010, Clause 5.

7 Impulse voltage tests

7.1 Installation

For preparation of the test installation, involving metal enclosures and terminal boxes, reference shall be made to the relevant standard.

~~In the case of three-core accessories (such as three single-core terminations in an enclosure), one phase shall be tested at a time, with the other two phases earthed.~~

The three phases of the three-core accessories can be tested together, unless the spaces between each phase are specified. In this case (such as three single-core terminations in an enclosure), each phase of the three-core accessories shall be tested at a time, with the other two phases earthed.

7.2 Method

The test shall be conducted according to the procedure given in ~~IEC 60230 (Clause 3 and following)~~ IEC 60230:2018, Clause 5, Clause 6, Clause 7, Clause 9 and Clause 10 and IEC 60230:2018/AMD1:2021, Clause 10, and shall be carried out at ambient temperature, unless otherwise specified.

7.3 Test at elevated temperature

The installation and the measurement of temperature are given in Clause 9.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of

– 5 K to 10 K above the maximum cable conductor temperature in normal operation for extruded insulation cables,
– 0 K to 5 K above the maximum cable conductor temperature in normal operation for paper insulated cables,

before and during the impulse test.

8 Partial discharge test

8.1 General

This test is only required for accessories for extruded insulation single-core cables and three-core cables with individually semi-conducting screened cores. It is not required for accessories incorporating paper insulated cables.

8.2 Method

The test shall be conducted in accordance with IEC 60270:2000 and IEC 60270:2000/AMD1:2015 and ~~IEC 60885-3~~ IEC 60885-2:1987[2] and shall be carried out at ambient temperature, unless otherwise specified.

The partial discharge shall be measured at the test voltage given in the relevant standard after maintaining the test object for 1 min at a pre-stressing voltage equal to the specified test voltage increased by 0,25 U_0.

8.3 Test at elevated temperature

The installation and the measurement of temperature are given in Clause 9.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of 5 K to 10 K above the maximum cable conductor temperature in normal operation, before and during the partial discharge test.

9 Tests at elevated temperature

9.1 Installation and connection

The accessories shall be erected, supported where necessary and provided with connections to permit heating current to be circulated.

Where terminations or separable connectors are to be tested, the connection between either lugs or bushings shall have an electrical cross-section equivalent to that of the cable conductor.

Where branch joints are to be tested, only the main cable shall carry the heating current.

Three-core accessories ~~may~~ can be connected for either single-phase or three-phase heating current. ~~Single-phase or three-phase voltage in accordance with requirements shall be superimposed on the heating current.~~ When heated with single-phase current a single-phase voltage shall be superimposed on the heating current. Respectively when heated with three-phase current a three-phase voltage shall be superimposed on the heating current. In the case of a magnetic covering, a three-phase heating current shall be applied.

Accessories for belted cables shall be subjected to three-phase voltage.

9.2 Measurement of temperature

9.2.1 Cable conductor temperature

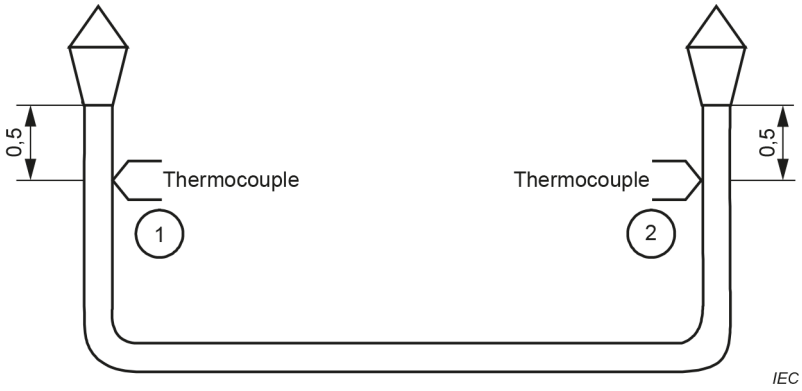
It is recommended that one of the methods described in Annex A is used to determine the actual conductor temperature.

9.2.2 Thermocouple position

If method 2 of Annex A is used to determine the conductor temperature, two thermocouples shall be attached to the cable sheath as shown in Figure 1 to Figure 6.

2 Withdrawn.

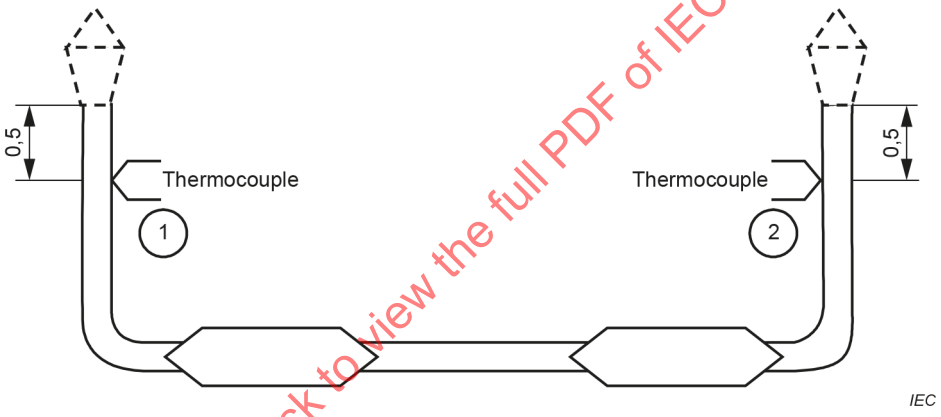
Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

Figure 1 – Terminations tested in air

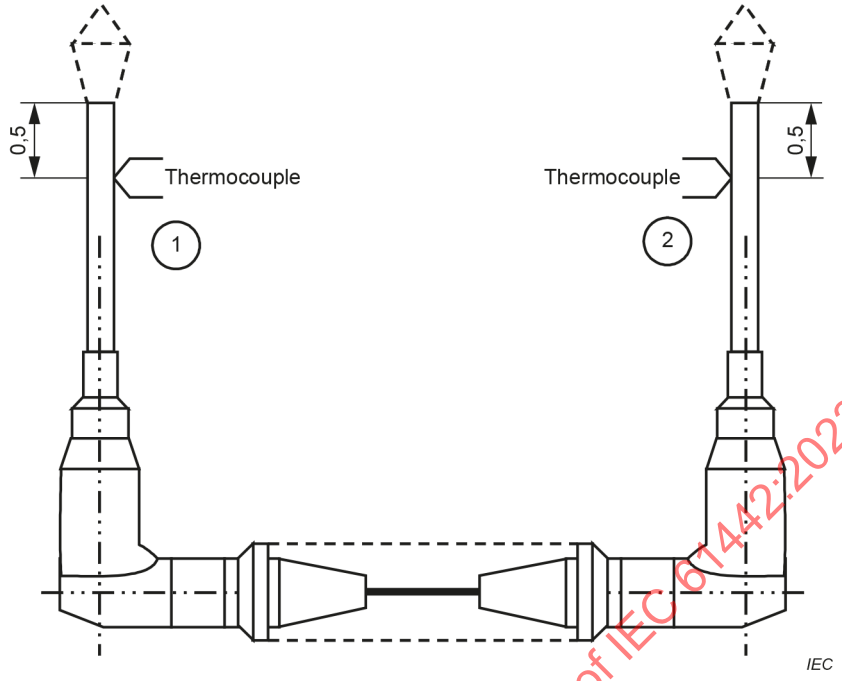
Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

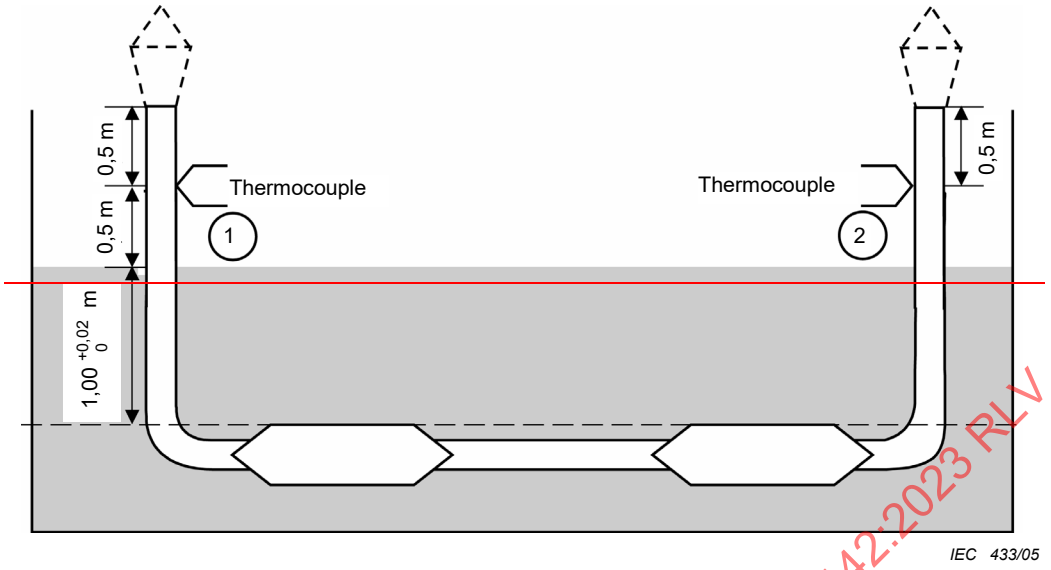
Figure 2 – Joints tested in air

Dimensions in metres

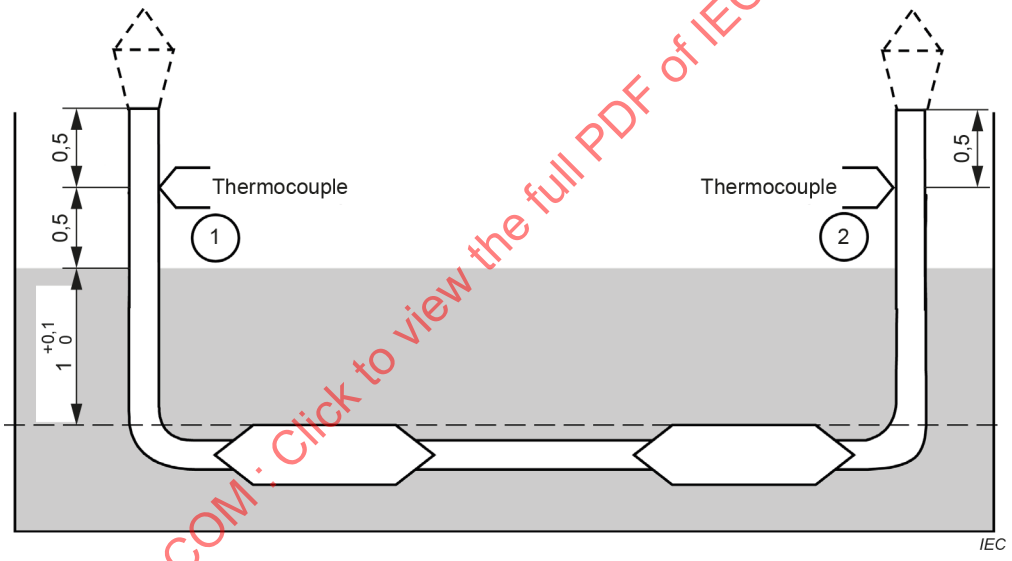


All distances mentioned to position thermocouples are minimum values.

Figure 3 – Separable connectors tested in air



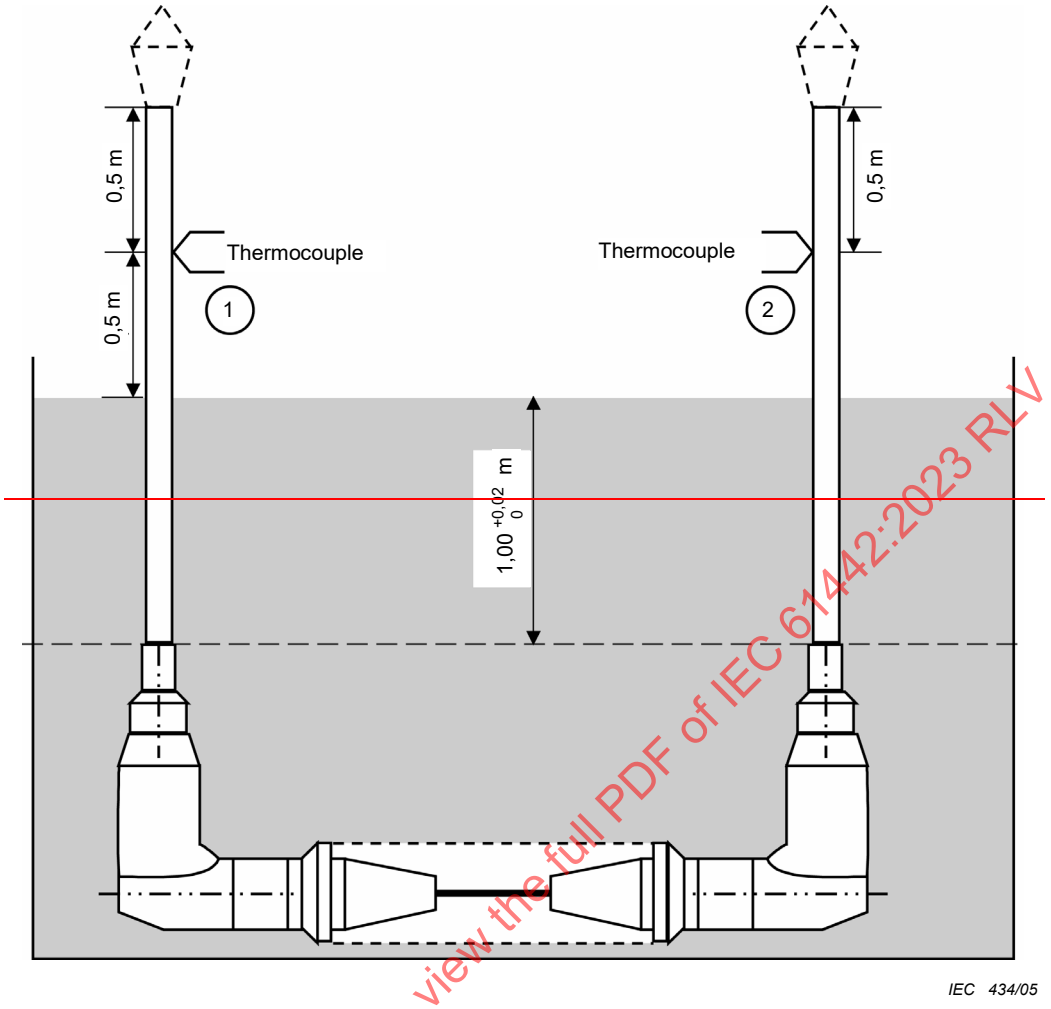
Dimensions in metres



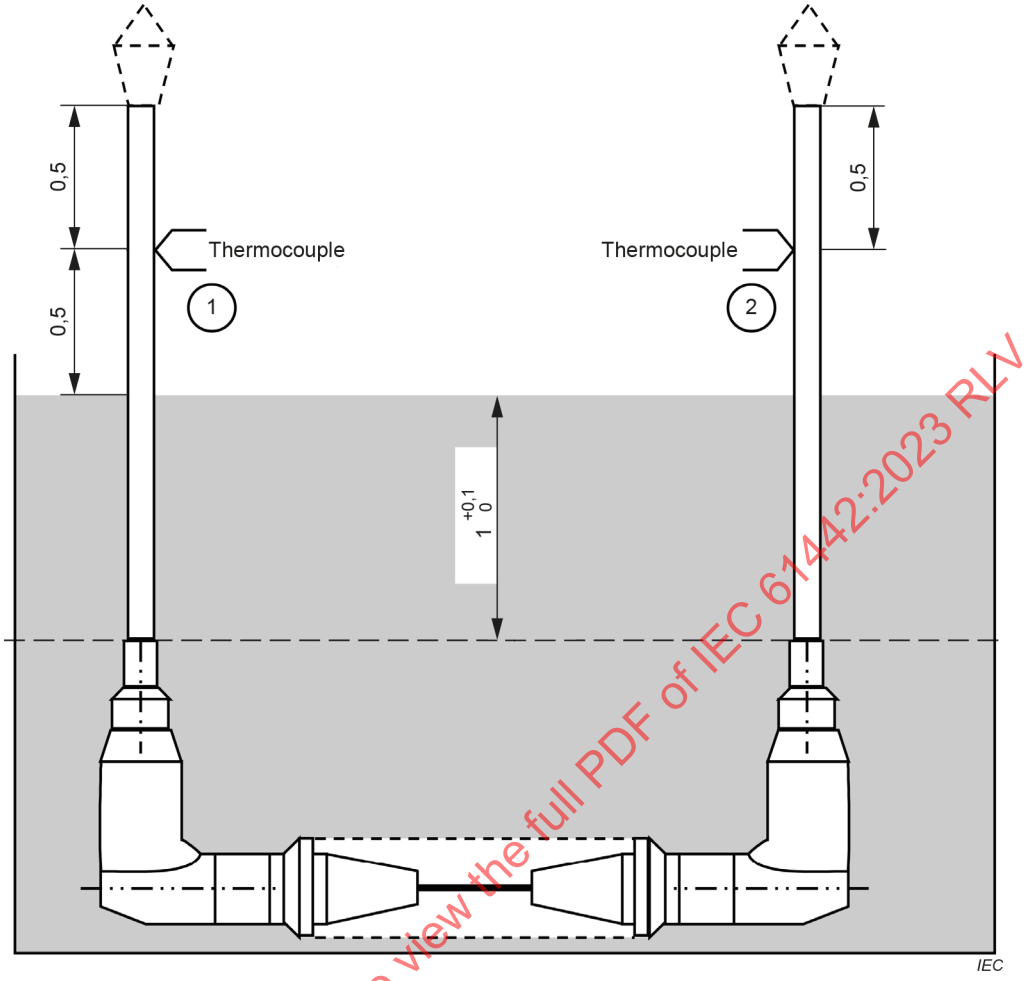
All distances mentioned to position thermocouples are minimum values.

NOTE The height of the water is as indicated, unless otherwise specified.

Figure 4 – Joints tested under water



Dimensions in metres

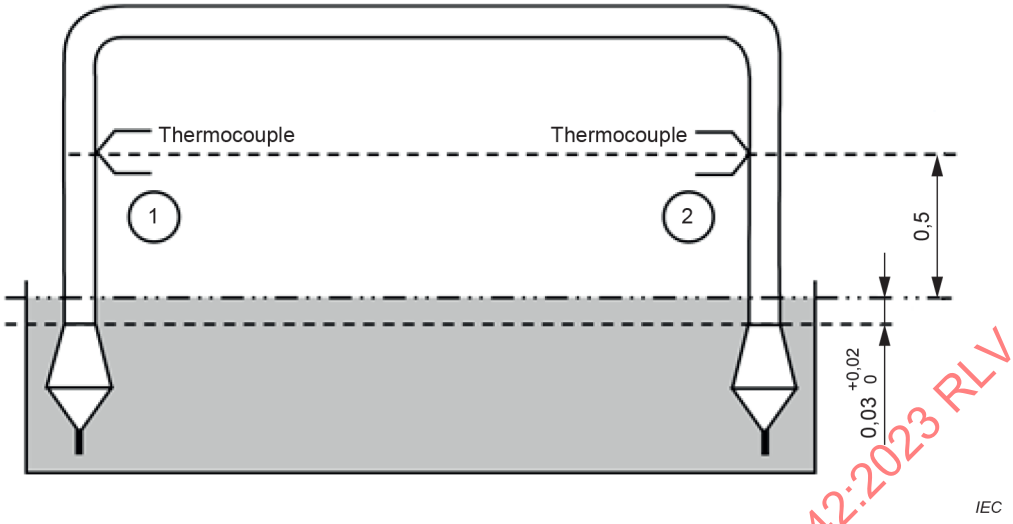


All distances mentioned to position thermocouples are minimum values.

NOTE The height of the water is as indicated, unless otherwise specified.

Figure 5 – Separable connectors tested under water

Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

Figure 6 – Outdoor terminations tested under water

10 Heating cycle voltage test

10.1 Installation and method

The arrangement for tests in air or water shall be as given in Clause 9.

The measurement of temperature is also given in Clause 9.

Each heating cycle in air or water shall be of at least 8 h duration with at least 2 h at a steady temperature:

– 5 K to 10 K above the maximum cable conductor temperature in normal operation for cables with extruded insulation ~~cables~~;

– 0 K to 5 K above the maximum cable conductor temperature in normal operation for paper insulated cables,

followed by at least 3 h of natural cooling to within 10 K of ambient temperature (see Figure 7).

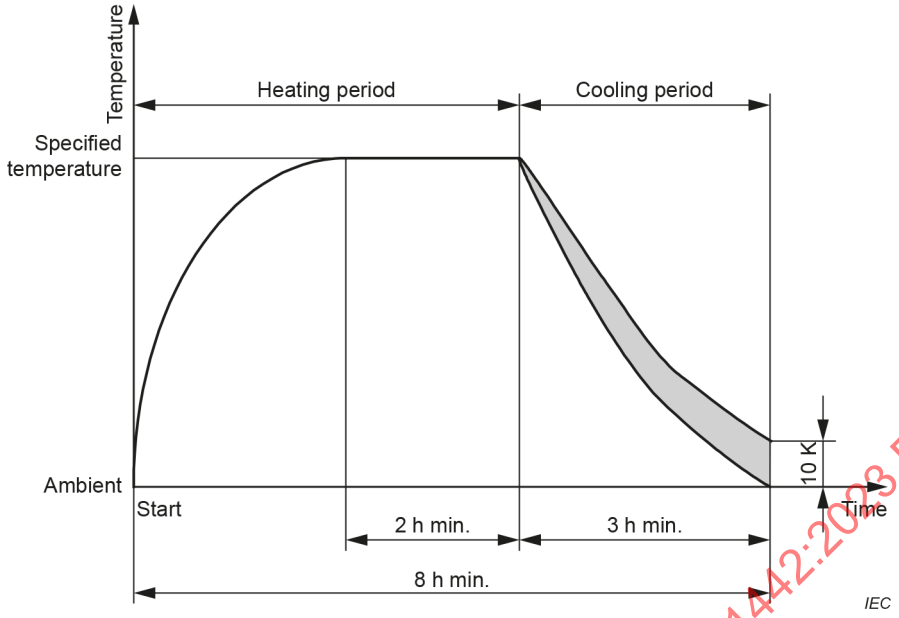


Figure 7 – Heating cycle

10.2 Test in air

The test assembly shall be subjected to the required number of heating cycles, energized at the voltage given in the relevant standard.

10.3 Test in water

For heat cycling in water, joints or separable connectors shall be installed in a vessel so as to have a height of water 1,00 $^{+0,1}_{0}$ m above the top surface of all accessories under test, unless otherwise specified. The water shall be at ambient temperature.

For accessories used with non-longitudinally water-blocked cable designs, the heating cycles voltage test under water shall be performed with oversheath damage. Expose the core(s) of one polymeric insulated cable at the entry to the accessory by removing an annulus of the oversheath, together with any bedding or filling material, of at least 50 mm in length, at a point which will be within the water and between 50 mm and 150 mm from the exterior of the accessory.

The exposure of the core(s) shall be made on the side with the shorter length between the oversheath cut and connectors.

NOTE The oversheath damage requirement does not apply to longitudinally water-blocked cable designs.

The test under water is not required for joints with a continuous metallic covering plumbed~~/~~ or welded to the cable metallic sheath.

The test assembly shall be subjected to the required number of thermal cycles, energized at the voltage given in the relevant standard.

After testing, the insulation resistance shall be measured between the conductor and metallic screen/sheath and the screen to water. The insulation resistance shall be measured between the screen and water only for cables without oversheath damage. The DC test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case, not less than 1 min and not more than 5 min.

10.4 Immersion test for outdoor terminations

10.4.1 Installation

~~Two~~ All the terminations of a the test loop shall be immersed in water at ambient temperature with a height of water $0{,}03\ ^{+0{,}02}_{0}$ m above every part of the terminations. The test loop shall be installed upside down in a water tank at ambient temperature, in such a way that the terminations are fully immersed in water, including the end of the sealing element (see Figure 6).

10.4.2 Method

The test loop shall be subjected to 10 cycles under the conditions given in 10.1. The test loop shall not be energized.

11 Thermal short-circuit test (screen)

~~This test is only required for accessories that are equipped with a connection to, or adaptor for, the metallic screen of the cable.~~

11.1 Installation

The test loop shall consist of the cable with its accessories.

The screen connections at both ends of the test loop shall be disconnected from earth and connected to a short-circuit generator. Accessories equipped with external earthing devices shall have these connections included in the short-circuit test.

The thermocouples to measure the screen temperature should be installed at minimum 0,5 m from the termination as shown in Figure 1, Figure 2 and Figure 3.

11.2 Method

The current (I_{sc}) and duration (t) for the test shall be agreed between the manufacturer and the customer, taking into account the actual short-circuit conditions of the network and the cable design. The duration (t) and current (I_{sc}) of the short-circuit shall be (1 ± 0,5) s up to a maximum current of 25 kA, if not otherwise specified. If the required short-circuit current exceeds this value a longer duration ≤ 5 s with a current between 25 kA and 45 kA shall be used.

The installation and the measurement of the conductor temperature are given in Clause 9.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of

– 5 K to 10 K above the maximum cable conductor temperature in normal operation for cables with extruded insulation ~~cables~~;
– 0 K to 5 K above the maximum cable conductor temperature in normal operation for paper insulated cables,

before carrying out the short-circuit test.

Before and after the short-circuits, the temperature of the screen shall be measured using thermocouples or any other suitable means. Measurement of the screen temperature is not necessary, if the time between the two stresses is longer than 1 h while continuing to apply heating current in the cable conductor.

Two short-circuits, corresponding to the current and time requirements agreed, shall then be applied to the screen. The achieved Joule integral (I^2t) shall be within 0 % and +10 % of the

calculated integral value. Between the two short-circuits, the cable screen shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first short-circuit.

If the current is not constant during the short-circuit, it is recommended to determine the RMS value of the short-circuit current using IEC 61238-1-3:2018, Annex E.

12 Thermal short-circuit test (conductor)

12.1 Installation

The test loop shall consist of the cable with its accessories.

Three-core accessories shall be tested with one end of the cable loop connected to the short-circuit generator and the other to a short-circuiting bar as described in the relevant standard. Alternatively, the three cores may be connected in series and tested as single-core accessories.

12.2 Method

The short-circuit method shall follow IEC 61238-1-3:2018, 6.4.1 and 6.4.2 with the following adjustment:

– The tests shall be carried out on the test loop at ambient temperature.

– Two short-circuits shall be applied using either alternating current or direct current ~~to raise the conductor temperature to the maximum permissible short-circuit temperature of the cable (θ_{sc}) within 5 s~~.

Between the two short-circuits, the test loop shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first short-circuit (θ_i). An alternative method to avoid having to measure the conductor temperature prior to the second short-circuit is to ensure that the test sample has cooled for > 3 h. If a cooling duration of > 3 h is applied, the I^2t of the first short-circuit applies also for the second short-circuit.

The maximum permissible short-circuit temperature of the cable conductor is given in ~~IEC 60986~~ IEC 60949:1988 and IEC 60949:1988/AMD1:2008.

The following formulae from ~~IEC 60986~~ IEC 60949:1988 and IEC 60949:1988/AMD1:2008 shall be used:

For aluminium conductors: $$I^2t = 2{,}19 \times 10^4 \times S^2 \times \ln\left(\frac{\theta_{sc} + 228}{\theta_i + 228}\right)$$

For copper conductors: $$I^2t = 5{,}11 \times 10^4 \times S^2 \times \ln\left(\frac{\theta_{sc} + 234{,}5}{\theta_i + 234{,}5}\right)$$

where

I is the RMS value of the short-circuit current (A);

t is the duration (s);

S is the conductor cross-sectional area (mm^2);

θ_{sc} is the permissible short-circuit conductor temperature (°C);

θ_i is the conductor temperature at the start of the test (°C);

ln is the $\log_e$.

If the current is not constant during the short-circuit, it is recommended to determine the RMS value of the short-circuit current using ~~Annex D of IEC 61238-1~~ IEC 61238-1-3:2018, Annex E.

13 Dynamic short-circuit test

13.1 General

This test is a three-phase test required for single-core cable accessories designed for initial peak currents ~~larger~~ higher than 80 kA and for three-core cable accessories designed for initial peak currents ~~larger~~ higher than 63 kA.

13.2 Installation

The test loop shall consist of either three single-core cables or a three-core cable with accessories.

One end of the test cable loop shall be connected to the short-circuit generator and the other to a short-circuiting bar, as described in the relevant standard.

For terminations, separable connectors and joints, the cable and accessories clamping method and the spacing between the accessories shall be as recommended by the manufacturer and shall be recorded in the test report. In addition, single-core cable joints shall be tested in a trefoil configuration with oversheaths in contact, unless a spaced trefoil is specified in which case the spacings shall be recorded.

13.3 Method

The short-circuit current shall be applied for a minimum of 10 ms to ensure that the initial peak current, as specified in the relevant standard, is reached.

The waveform shall be recorded.

NOTE In practice, clearance times of the order of 60 ms ~~may~~ can be expected. Exceeding this time ~~may~~ can cause thermal problems with the cable or accessory.

14 Humidity and salt fog tests

14.1 Apparatus

A single- or three-phase AC voltage source is required. The maximum voltage drop at the high voltage side of the source shall be less than 5 % at 250 mA leakage current during the test.

A humidity test chamber shall be used, equipped with spray nozzles or other form of humidifier capable of discharging atomized water at a rate of (0,4 ± 0,1) l/h/m^3 volume. Throughout the test duration, the spray water conductivity shall be (70 ± 10) mS/m for humidity tests and (1 600 ± 200) mS/m for salt fog tests. The chamber shall be designed such that no water drips directly on the accessories during the test.

Guidance on the test chamber and on the spray equipment is given in Annex B.

14.2 Installation

The test accessories shall be installed in the humidity chamber with the accessories having the same orientation and relative spacing as installed in service, and according to the manufacturer's instructions.

Three unscreened separable connectors or three shrouded terminations shall be mounted in a test terminal box and subjected to a three-phase voltage.

The three-core terminations shall also be subjected to a three-phase voltage.

In the case of a compact installation of three single-core terminations, it is recommended to carry out the test with a three-phase voltage.

The phase(s) of the transformer shall be protected with an automatic tripping device, connected to the current measuring source, set to de-energize the circuit when a leakage current of (1,0 ± 0,1) A RMS flows in the high-voltage circuit for a period between 50 ms and 250 ms.

14.3 Method

The humidity chamber during the tests shall be at ambient temperature.

The duration and the voltage of the tests are given in the relevant standard.

Up to 5 % of the testing duration shall be permitted in breaks. Cleaning of the accessories or any other form of similar interference shall not be permitted during the test.

The accessories shall be photographed in colour in at least two opposite directions before commencement and after completion of the test. Photographs shall clearly show the condition of the leakage path.

The condition of the samples shall be noted at the end of the test.

The test results shall record the occurrence of any flashover, a description and photographs of the condition of the accessories, particularly any tracking, erosion or mechanical damage. This information shall be included in the test report.

15 Impact test at ambient temperature

The test shall be carried out on joints, transition-joints and branch-joints only.

Prior to impacting, the insulation resistance shall be measured between the conductor and the metallic screen/sheath. The DC test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case, not less than 1 min and not more than 5 min.

~~NOTE~~ If more than one joint is included in the loop, provision ~~should~~ shall be made for the insulation resistance of each joint to be measured separately.

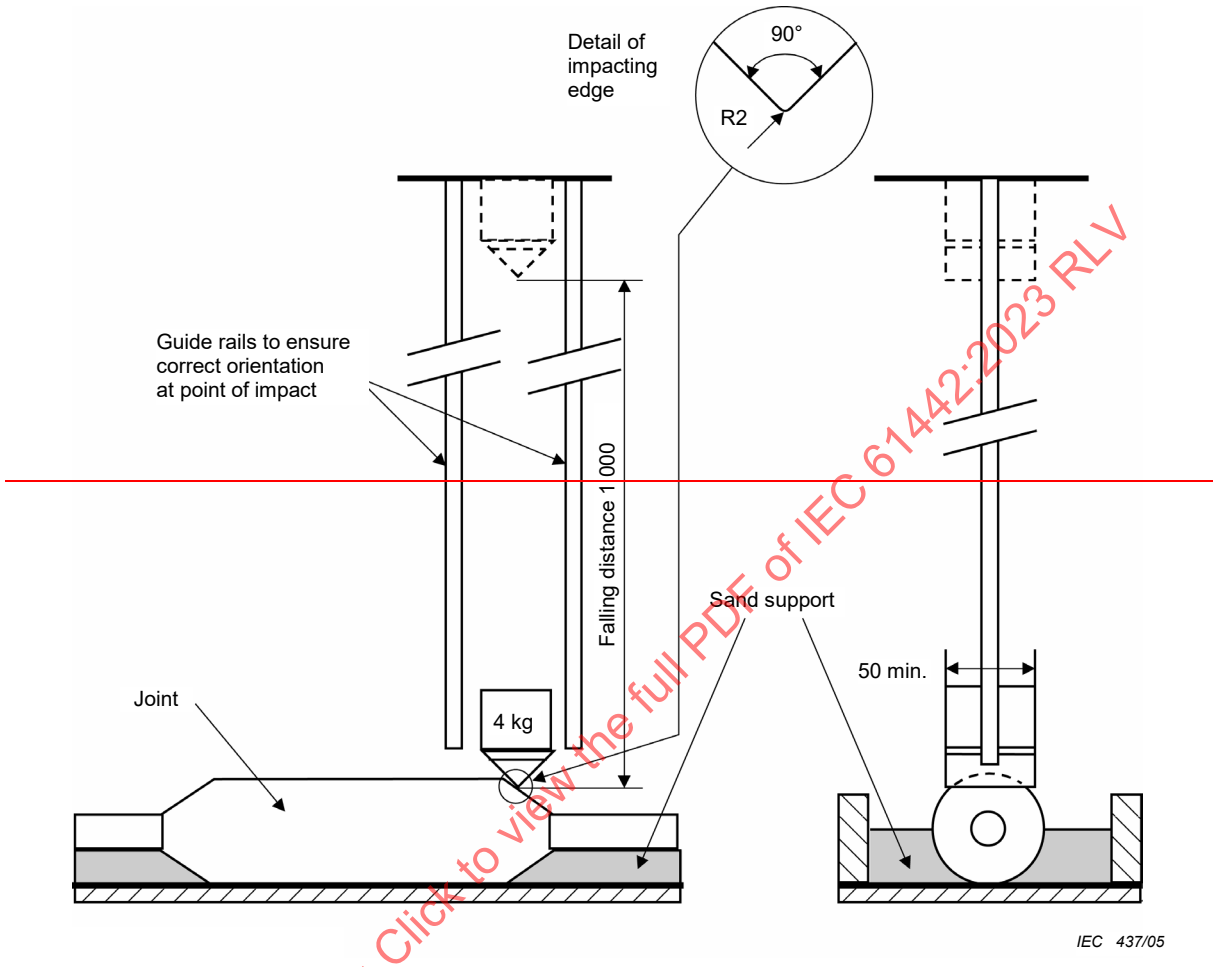
The joint shall be placed on a hard base, for example a concrete slab or floor, and solidly supported in a box filled with sand up to the horizontal centre line of the accessory (see Figure 8).

A wedge shaped steel block of (4,00 ± 0,05) kg having a (90 ± 1)° angle with a (2 ± 0,4) mm radius impacting edge shall be dropped freely from a height of (1,0 ± 0,01) m onto the joint so that the impacting edge is horizontal and at right angles to the axis of the joint. There shall be one impact at each end of the joint and one impact at a position over the conductor connectors. The impact at the end of the joint shall be at the oversheath cut in the case of an extruded insulation cable and at the metallic sheath cut in the case of a metallic sheathed cable.

After the impact test, the joint shall be immersed in water at ambient temperature with a height of water $1{,}00\ ^{+0,1}_{0}$ m over the top surface of the joint for a minimum of 3 h. The insulation resistance shall then again be measured as specified above between the conductor and the metallic screen/sheath and between the metallic screen/sheath (if insulated) and the water.

Details of visible effects and position of the impacts on the joint shall be recorded by photographs in the test report.

Dimensions in millimetres



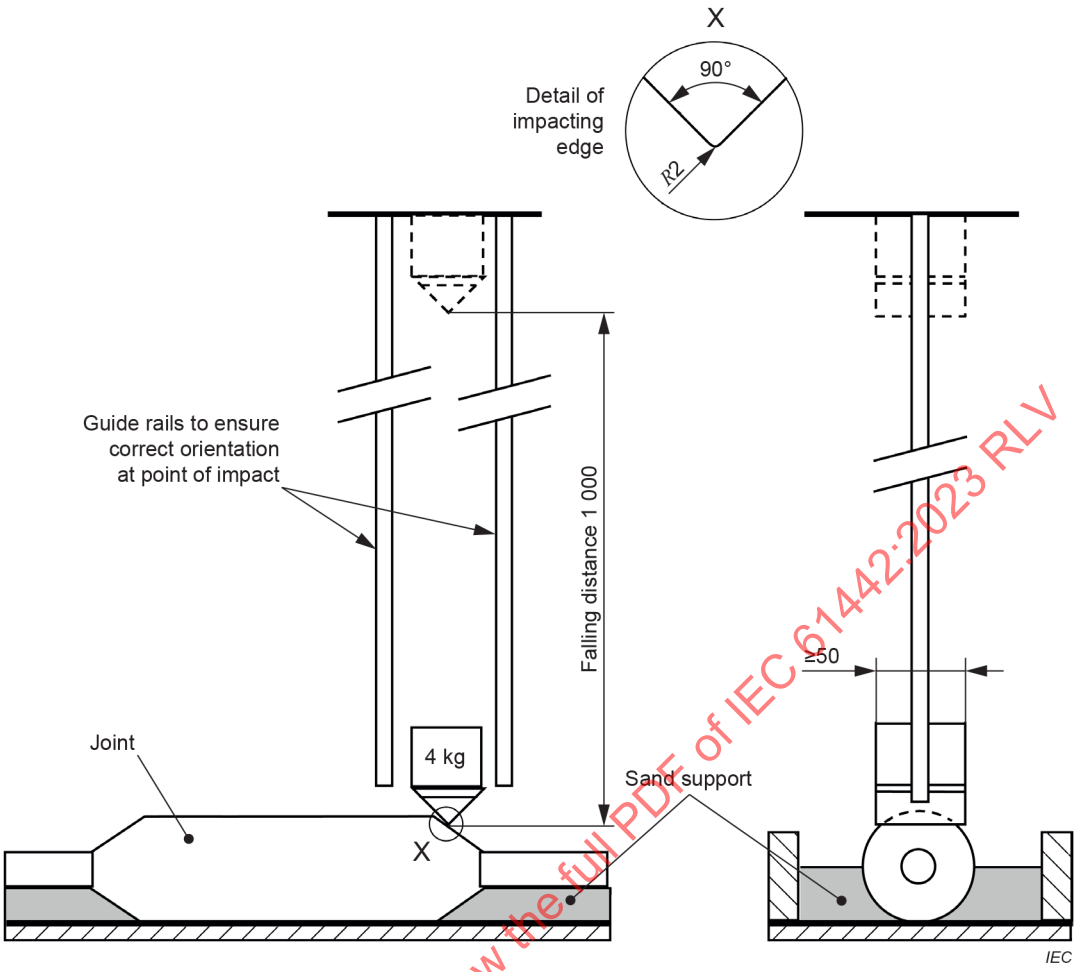


Figure 8 – Typical impact test apparatus for joints

16 Screen resistance measurement

16.1 General

The purpose of this test is to ensure that if a separable connector is touched by hand when it is in service, no electrical shock is experienced.

This test shall be carried out on separable connectors without a metallic housing or with a removable metallic housing. The metallic housing shall be removed prior to the test.

This test is not required for separable connectors which can only be used in service with the metallic housing in position.

16.2 Installation

The test shall be carried out on a separable connector which does not ~~need~~ require to be installed on either a cable or a mating bushing. Silver painted or wraparound electrodes shall be installed at each end of the separable connector.

16.3 Method

The screen resistance of the separable connector shall be measured at ambient temperature between the two electrodes. The power dissipation of the test circuit shall not exceed 100 mW.

The sample shall then be subjected to thermal ageing in an air oven at (120 ± 2) °C for 168 h under the conditions described in ~~8.1 of IEC 60811-1-2~~ IEC 60811-401:2012.

The separable connector screen resistance at ambient temperature shall be measured again as above.

17 Screen leakage current measurement

17.1 General

The purpose of this test is to ensure that if a separable connector is touched by hand when it is in service, no electrical shock is experienced.

This test is required for separable connectors without a metallic housing or with a removable metallic housing. The metallic housing shall be removed prior to the test.

This test is not required for separable connectors which can only be used in service with the metallic housing in position.

17.2 Installation

A separable connector shall be installed on a length of cable and connected to its mating bushing.

17.3 Method

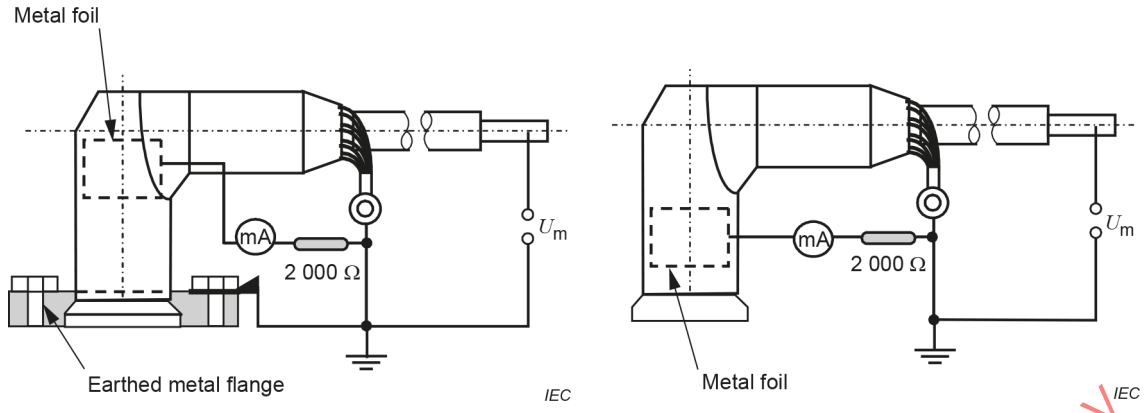
The test shall be carried out at ambient temperature.

A metal foil of 50 mm × 50 mm, shall be fixed without any air gap to the outer screen of the separable connector as far as possible from the earthing points:

– in the case of separable connectors with an earthed metal flange (see Figure 9 a)), the metal foil shall be placed mid-way between the metal flange and the earth bond of the cable screen;
– in the case of separable connectors without a metal flange (see Figure 9 b)), the metal foil shall be placed at the end of the separable connector opposite to the earth bond of the cable screen.

In both cases, the metal foil shall be earthed through a milliammeter and a resistance of 2 000 Ω, as shown in Figure 9.

The leakage current shall be measured with an AC test voltage of U_m applied between the conductor and earth.



a) With an earthed metal flange **b) Without an earthed metal flange**

Figure 9 – Test arrangement for the screen leakage current measurement

18 Screen fault current initiation test

18.1 General

The purpose of this test is:

a) in the case of a solidly earthed system or resistance earthed system, in which the first earth fault is cleared,

to demonstrate the ability of the separable connector screen to initiate a fault to earth which produces sufficient current to operate the circuit protection, should its insulation fail;

b) in the case of an unearthed or impedance earthed system, in which the first earth fault is held,

to demonstrate the ability of the separable connector screen to initiate and sustain a fault current to earth, should its insulation fail.

The test is applicable only to screened separable connectors and shall be carried out with the connectors installed as in service.

This test is required for separable connectors without a metallic housing or with a removable metallic housing. The metallic housing shall be removed prior to the test.

This test is not required for separable connectors which can only be used in service with the metallic housing in position.

18.2 Installation

A separable connector shall be assembled on a cable in accordance with the manufacturer's instructions. All parts of the separable connector which are normally earthed shall be connected to the cable screen, including the bushing screen.

For testing separable connectors used in solidly earthed systems, the faulting rod shall be of erosion resistant metal, ~~approximately~~ (10 ± 0,5) mm in diameter and threaded at one end to engage the accessory metal connector through a drilled hole. The rod shall be in contact with the inner and outer screens and shall not protrude beyond the outer screen surface, as shown in Figure 10.

For separable connectors used in unearthed systems or impedance earthed systems, the faulting rod shall be replaced by a copper wire of approximately 0,2 mm in diameter. The wire shall be in contact with the inner and outer screens and shall not protrude beyond the outer screen surface, as shown in Figure 10.

18.3 Method

18.3.1 Solidly earthed system

The test shall be carried out at ambient temperature.

The circuit shall be adjusted to impose the separable connector phase-to-earth voltage U_0 on the test specimen and a short-circuit current of (10 ± 0,5) kA RMS. The test specimen shall be subjected to two tests that cause initiation of a fault current arc to earth, each operation having a minimum current flow duration of 0,2 s. Between the two tests, the test sample shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first test.

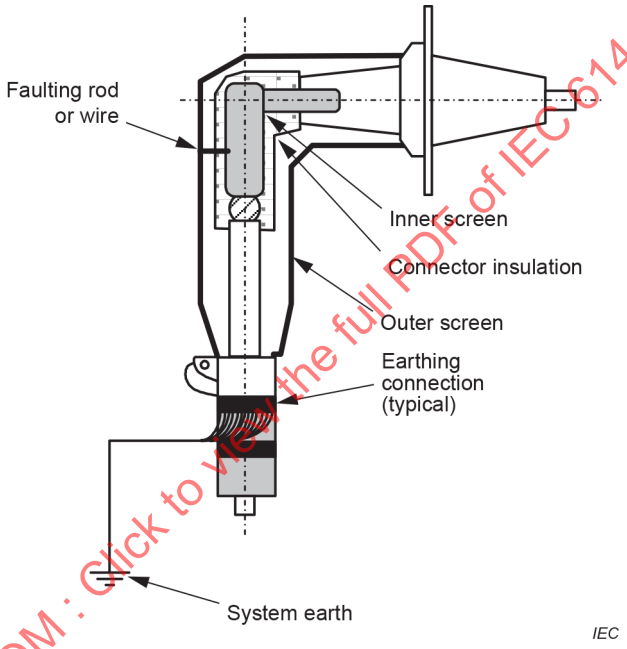


Figure 10 – Test arrangement for screen fault current initiation test

18.3.2 Unearthed or impedance earthed system

The test shall be carried out at ambient temperature.

The circuit shall be adjusted to impose the separable connector phase-to-earth voltage U_0 on the test specimen and a short-circuit current of at least 10 A RMS.

The current for the short-circuit test shall be agreed upon between the manufacturer and the customer, taking into account the actual short-circuit conditions of the network.

The test voltage and current shall be recorded continuously during the entire period. The sequence of the test shall be as follows:

a) voltage switched on for 1 s;

b) voltage switched off for 2 min;

c) voltage switched on for 2 min;

d) voltage switched off for 2 min;

e) voltage switched on for 1 min;

f) voltage switched off.

19 Operating force test

19.1 General

This test is only required for screened separable connectors equipped with a sliding contact.

19.2 Installation

A separable connector shall be assembled in accordance with the manufacturer's instructions and connected to its mating bushing, using the lubricant supplied by the manufacturer.

19.3 Method

The separable connector assembly shall be conditioned at (−20 ± 2) °C for at least 12 h. The test shall be carried out within 5 min after removal from the conditioning chamber. The separable connector shall be clamped by means of a suitable tool which allows operation along the axis of the separable connector and mating bushing interface.

A force shall be gradually applied to the separable connector in the axial direction. The force to open and close the separable connector~~/~~ and bushing interface shall be measured.

20 Operating eye test

20.1 General

This test is only required for screened separable connectors equipped with a sliding contact.

20.2 Installation

A separable connector shall be assembled on a cable loop in accordance with the manufacturer's instructions and connected to its mating bushing, using the lubricant supplied by the manufacturer. The separable connector shall be mechanically clamped along the interface.

20.3 Method

The test shall be carried out at ambient temperature.

A tensile force shall be gradually applied to the operating eye with a suitable tool in the direction of the bushing axis up to the specified force and maintained for the specified time as given in the relevant standard.

A rotational torque shall then be gradually applied, up to the specified value given in the relevant standard, using a suitable tool first in a clockwise direction and then in an anticlockwise direction.

21 Capacitive test point performance

21.1 General

This test is only required for screened separable connectors with a capacitive divider.

21.2 Installation

A separable connector shall be installed on a cable and the outer screen earthed in accordance with the manufacturer's instructions. It is not necessary for the separable connector to be connected to its mating bushing. It is recommended that the length of cable used be as short as possible.

21.3 Test method

Since the capacitances to be measured are very small, the use of a differential bridge is recommended in order to eliminate the influence of stray capacitances.

The following capacitances shall be measured at ambient temperature:

– C_{tc}: capacitance between the test point and the cable conductor;

– C_{te}: capacitance between the test point and the earth.

Annex A
(informative)

Determination of the cable conductor temperature

A.1 Purpose

For some of the accessory tests, it is necessary to raise the cable conductor to a given temperature, typically 5 K to 10 K above the maximum temperature in normal operation, while the cable is energized, either at power frequency or under impulse conditions. It is therefore not possible to have access to the conductor to enable the direct measurement of temperature.

In addition, the conductor temperature should be maintained within a restricted range (5 K), whereas the ambient temperature may vary over a wider range.

Thus, it is necessary to carry out a preliminary calibration on the test cable to determine the actual conductor temperature during the accessory tests, allowing for the permitted variation in ambient temperature.

Guidance is given hereafter on commonly used methods.

A.2 Calibration of the test cable conductor temperature

A.2.1 General

The purpose of the calibration is to determine the conductor temperature by direct measurement for a given current, within the temperature range required for the test.

The cable used for calibration should be identical to that to be used for the accessory test.

A.2.2 Installation of cable and thermocouples

The calibration should be performed on a minimum cable length of 2 m, the thermocouples being installed at 0,5 m from the cable ends, as shown in Figure A.1.

At each place, two thermocouples should be attached: one on the conductor (a), and one on the external surface (b), as shown in Figure A.2.

NOTE The thermocouples (b) on the external surface are only necessary if the method in A.3.3 is used.

It is recommended that the thermocouples are attached to the conductor by mechanical means since they ~~may~~ can move due to vibrations of the cable conductor during heating.

If the actual test loop includes several individual cable lengths installed close to each other, these lengths will be subjected to thermal proximity effect. The calibration should therefore be carried out taking account of the actual test arrangement, measurements being performed on the hottest cable length (usually the middle length).

Dimensions in metres

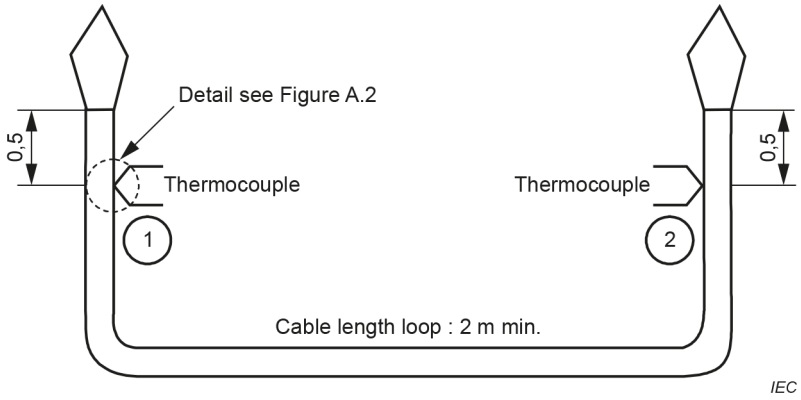
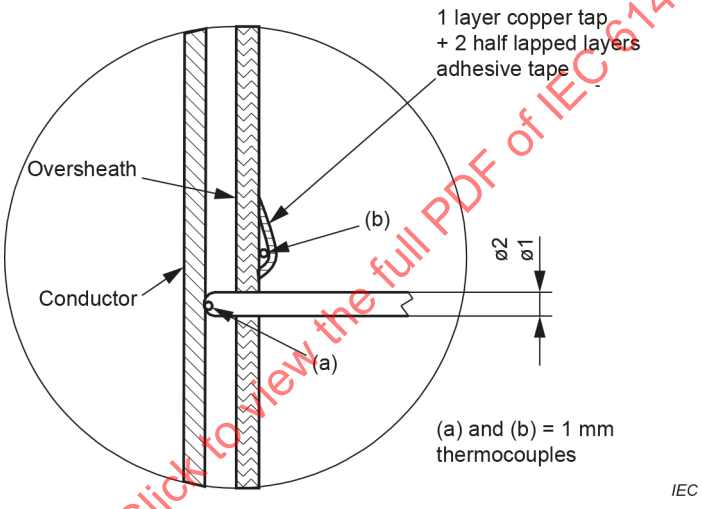


Figure A.1 – Reference cable

Dimensions in millimetres



NOTE Optionally the thermocouple can be welded to the copper tape at (b).

Figure A.2 – Arrangement of the thermocouples

A.2.3 Method

The calibration should be carried out in a draught free situation at a temperature between 5 °C and 35 °C.

Temperature recorders should be used to measure the conductor, sheath and ambient temperatures.

The cable should be heated until the conductor temperatures a_1 and a_2, indicated by thermocouples (a) at positions 1 and 2 of Figure A.1, have stabilized and reached the temperatures given below:

– between 5 K and 10 K above the maximum conductor temperature of the cable in normal operation, as given in the relevant standard for extruded insulation cables;
– between 0 K and 5 K above the maximum conductor temperature of the cable in normal operation, as given in the relevant standard for paper insulated cables.

It is considered that stabilization has been reached if the conductor temperatures, a_1 and a_2, do not show any variation larger than 2 K within a 2 h period.

When stabilization has been reached, the following should be noted:

~~– conductor temperature $\theta_{cond} = \frac{(a_1 + a_2)}{2}$~~

~~– sheath temperature $\theta_{sheath.c} = \frac{(b_1 + b_2)}{2}$~~

~~– ambient temperature $\theta_{amb.c}$~~

~~– heating current I_{cal}~~

– $\theta_{cond} = \frac{(a_1 + a_2)}{2}$;

– $\theta_{sheath.c} = \frac{(b_1 + b_2)}{2}$;

– $\theta_{amb.c}$;

– I_{cal};

where

θ_{cond} is the temperature of the conductor;

$\theta_{sheath.c}$ is the external temperature of the sheath during calibration;

$\theta_{amb.c}$ is the ambient temperature during calibration;

I_{cal} is the current during calibration.

A.3 Heating for accessory test

A.3.1 General

R_{20} is the resistance per unit length of conductor at 20 °C (see IEC 60228);

α_{20} is the temperature coefficient of resistance at 20 °C (see IEC 60228);

T is the thermal resistance between the conductor and the surrounding medium (including T_4, the thermal resistance of air);

T' is the thermal resistance between the conductor and the external surface of cable (excluding T_4, the thermal resistance of air).

NOTE According to the IEC 60287 series calculation methodology: $T' = T_1 + nT_2 + nT_3$

where

n = 1 for single-core cables;

n = 3 for three-core cables;

$T = T' + nT_4$.

$\theta_{amb.t}$ is the ambient temperature during the accessory test;

$\theta_{sheath.t}$ is the temperature of the external surface during the accessory test;

I_{test} is the current during the accessory test.

A.3.2 Method 1: Test based on measurement of ambient temperature

Assuming that dielectric, metallic sheath and armour losses are negligible:

– during the cable calibration:

$$\theta_{cond} - \theta_{amb.c} = R_{20} \times I^2_{cal} [1 + \alpha_{20} (\theta_{cond} - 20)]T \quad (A.1)$$

– during the accessory test:

$$\theta_{cond} - \theta_{amb.t} = R_{20} \times I^2_{test} [1 + \alpha_{20} (\theta_{cond} - 20)]T \quad (A.2)$$

(it is assumed that T, and particularly T_4, have not changed).

Combining Equations (A.1) and (A.2) gives:

$$I_{test} = I_{cal} \sqrt{\frac{\theta_{cond} - \theta_{amb.t}}{\theta_{cond} - \theta_{amb.c}}} \quad (A.3)$$

A.3.3 Method 2: Test based on measurement of the external surface temperature

– during the cable calibration:

$$\theta_{cond} - \theta_{sheath.c} = R_{20} \times I^2_{cal} [1 + \alpha_{20} (\theta_{cond} - 20)]T' \quad (A.4)$$

– during the accessory test:

$$\theta_{cond} - \theta_{sheath.t} = R_{20} \times I^2_{test} [1 + \alpha_{20} (\theta_{cond} - 20)]T' \quad (A.5)$$

Combining Equations (A.4) and (A.5) gives:

$$I_{test} = I_{cal} \sqrt{\frac{\theta_{cond} - \theta_{sheath.t}}{\theta_{cond} - \theta_{sheath.c}}} \quad (A.6)$$

It should be noted that Equation (A.4) allows the determination of the internal thermal resistance T' of the cable from readings of temperature and current.

Equation (A.5) can be written in the form:

$$\theta_{cond} = \frac{\theta_{sheath.t} + (1 - 20\,\alpha_{20})\,R_{20}\;I^2_{test}\;T'}{1 - \alpha_{20}\;R_{20}\;I^2_{test}\;T'} \quad (A.7)$$

It is therefore possible to transpose Formula (A.7) in the form of a chart, as shown in Figure A.3, giving θ_{cond} from $\theta_{sheath.t}$ readings, for various values of the heating current $I_{test\ 1}$, $I_{test\ 2}$, etc.

The use of such a chart is advisable if the test is not automatically controlled.

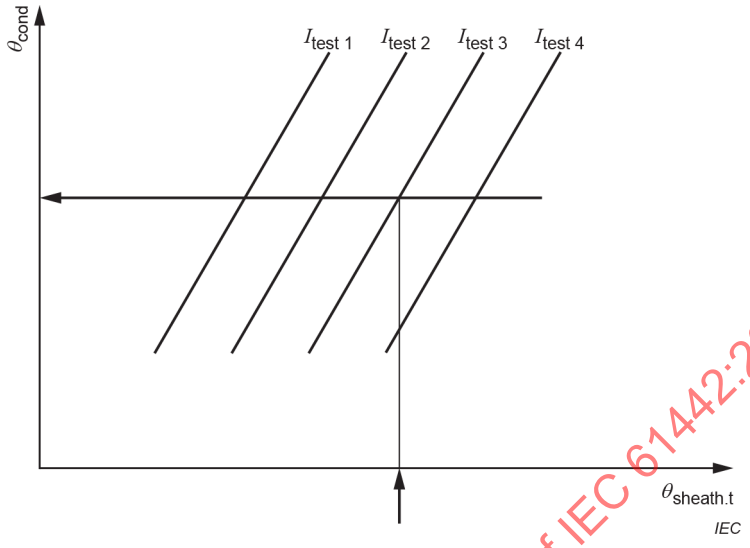


Figure A.3 – Current~~I~~ and temperatures curves

A.3.4 Method 3: Test using a control cable

In this method, a control cable identical to the cable used for the test is heated with the same current as the test loop. This cable is not energized and therefore thermocouples can be fitted to the conductor as recommended in A.2.2 above.

The test arrangement should be such that

– the control cable ~~should carry~~ carries the same current as the test loop at any time,

– it ~~should be~~ is installed in such a way that mutual heating effects are taken into account throughout the test,

– for the test in water, the control cable remains in air in a draught free situation.

The thermocouples should be mounted on the external surface of the test loop at the positions given in Figure A.1, in the same way as the thermocouples are mounted on or under the surface of the control cable.

NOTE The temperatures measured with the thermocouples on the oversheath of the energized test loop and of the control cable, are used to check whether the oversheath of both test loops has the same temperature.

The temperature measured with the thermocouple fitted to the conductor of the control loop may be considered as representative for the conductor temperature of the energized test loop.

All thermocouples should be connected to a temperature recorder to enable temperature monitoring. The heating current of each test loop should be recorded to prove that the two currents are of the same value throughout the duration of the test. The difference between the heating currents should be kept within ±1 %.

The heating current is adjusted so that the conductor temperature is kept within the specified limits.

Annex B
(informative)

Details of the test chamber and spray equipment for humidity and salt fog tests

B.1 Test chamber

The dimensions of the test chamber should be adequate to contain the number of accessories being tested simultaneously, having due regard to the size of the accessory, the test voltage, safety clearances and stray electric fields, and the ratio of chamber volume to number of spray producing nozzles.

It should be constructed from corrosion resistant, waterproof materials. Temporary structures may be used. All high voltage bushings and support insulators should be mounted on earthed supports to ensure that an electric field does not exist along the surface of the chamber. The chamber should incorporate observation ports.

When the voltage supply (three-phase or single-phase, as appropriate) is introduced into the chamber through suitable bushings, such bushings should be well spaced to avoid interaction between adjacent phases. The length of the bushings within the test chamber should be designed with a long creepage length and deep undercuts in the skirt design to resist flashover.

A drain should be provided to conduct water out and away from the test chamber. The chamber should be so designed so as to prevent corrosion products or other contamination from dripping on the accessories during the test. The test chamber may be ventilated to prevent a build-up of pressure inside, but any such ventilation should not allow a significant amount of vapour or fog to escape to the atmosphere.

For the humidity and salt fog tests, means should be provided for measuring the rate of flow of solution into the atomizing sprays.

B.2 Spray equipment for humidity and salt fog tests

Humidity and salt fog tests may be conducted using the air nozzle spraying system described in IEC 60507. The equipment should be designed to run continuously for the duration of the test.

The nozzles should be set to blow fog into the test chamber. The fog should not be blown directly on the accessories but should fill the test chamber and circulate freely among the accessories by the action of fog~~/~~ and air currents. At least 80 % of the water ejected by the nozzles should be atomized into droplets not greater than 10 µm in diameter.

Alternatively, proprietary equipment is available for atomizing water and salt solution, which ~~may~~ can be more convenient for the manufacturer conducting the tests. Use of such equipment should not be discouraged, but it is a pre-requisite that the manufacturer produces information showing that his equipment has the capacity to fill the test chamber adequately with the correct size of atomized water droplets.

B.3 High voltage transformers

For three-phase testing, a three-phase or three single-phase transformers should be used to energize the accessories under test. Single-phase transformers should be star-connected with the neutral point earthed. The voltage in the test circuit should remain stable and practically unaffected by varying leakage currents. The output voltage may be controlled by varying the low voltage supply to the transformers, and it should be possible to measure or calibrate the output voltage.

Bibliography

IEC 60055-1:1997, *Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV (with copper or aluminium conductors and excluding gas-pressure and oil-filled cables) – Part 1: Tests on cables and their accessories*
IEC 60055-1:1997/AMD1:2005

IEC 60228, *Conductors of insulated cables*

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

IEC 60502-2, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60507:~~1991~~2013, *Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems*

IEC 60986:2000, *Short-circuit temperature limits of electric cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*
IEC 60986:2000/AMD1:2008

IEC 62475:2010, *High-current test techniques – Definitions and requirements for test currents and measuring systems*

IEC 61442

Edition 3.0 2023-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Test methods for accessories for power cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)

Méthodes d'essais des accessoires de câbles d'énergie de tensions assignées de 6 kV (U_m = 7,2 kV) à 30 kV (U_m = 36 kV)

IEC 61442:2023-10(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TEST METHODS FOR ACCESSORIES FOR POWER CABLES WITH RATED VOLTAGES FROM 6 kV (U_m = 7,2 kV) UP TO 30 kV (U_m = 36 kV)

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This third edition cancels and replaces the second edition published in 2005. This edition constitutes a technical revision.

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

a) 4.6 – the option to start tests immediately has been included;
b) 4.11 – methods for testing on belted cables have been included;
c) 5.3.2 and 10.3 – details of insulation resistance testing has been added;
d) 8.2 – pre-stress with slightly increased test voltage before applying the partial discharge test has been included;
e) 11.2 – testing of accessories with external earthing devices has been included;
f) 11.2 – short-circuit duration and maximum kA levels have been added;

g) 11.2 – temperature measurement is not required if the time between short-circuits > 1 h.

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

Draft	Report on voting
20/2108/FDIS	20/2132/RVD

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

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

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The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

TEST METHODS FOR ACCESSORIES FOR POWER CABLES WITH RATED VOLTAGES FROM 6 kV (U_m = 7,2 kV) UP TO 30 kV (U_m = 36 kV)

1 Scope

This document specifies the test methods applicable for type testing accessories for power cables with rated voltages from 3,6/6 (7,2) kV up to 18/30 (36) kV. The test methods specified in this document apply to accessories for extruded and paper insulated cables according to IEC 60502-2 and IEC 60055-1 respectively.

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 60230:2018, *Impulse tests on cables and their accessories*
IEC 60230:2018/AMD1:2021

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*
IEC 60270:2000/AMD1:2015

IEC 60811-401:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*
IEC 60811-401:2012/AMD1:2017

IEC 60885-2:1987[1], *Electrical test methods for electric cables – Part 2: partial discharge tests*

IEC 61238-1-3:2018, *Compression and mechanical connectors for power cables – Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) tested on non-insulated conductors*

IEC 60949:1988, *Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects*
IEC 60949:1988/AMD1:2008

[1] Withdrawn.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Test installations and conditions

4.1 The test methods described in this document are intended to be used for type tests.

4.2 The test arrangements and the number of test samples are given in the relevant standard.

4.3 The test conditions are specified in Clause 5 to Clause 21. When they are not, they shall be as specified in the relevant standards.

4.4 The testing parameters and the requirements are given in the relevant standard, unless otherwise stated.

4.5 For transition joints (either extruded insulation to extruded insulation or extruded insulation to paper insulation), the testing parameters (voltage and conductor temperature) are those of the lower rated cable.

4.6 The tests can be started immediately after installation of accessories on the cable test loops, unless otherwise specified by the manufacturer. The time interval between installation of the accessories and the start of the tests shall be recorded in the test report.

4.7 Cable screens, and armour if any, shall be bonded and earthed at one end only to prevent circulating currents.

4.8 All parts of an accessory which are normally earthed shall be connected to the cable screen. Any supporting metalwork shall also be earthed.

4.9 The ambient temperature shall be (20 ± 15) °C.

4.10 Tap water shall be used for all tests in water.

4.11 Tests on belted cables:

When conducting AC voltage tests and heating cycle voltage tests, a three-phase test voltage and current system shall be used.

When conducting DC voltage tests and the impulse tests, the test voltage shall be applied to one cable conductor and the other two cable conductors and the screen shall be earthed. All cable conductors shall be tested separately.

5 AC voltage tests

5.1 Dry test for all accessories

5.1.1 Installation

The set(s) of accessories shall be erected with all associated metalwork and fittings. The accessories shall be clean and dry before applying the test voltage.

5.1.2 Method

The test shall be made at ambient temperature, and the procedure for voltage application shall be as specified in IEC 60060-1:2010, Clause 6, unless otherwise specified.

5.2 Wet test for outdoor terminations

5.2.1 Installation

The terminations shall be erected in a vertical position, unless they are to be specifically installed in another orientation, with the relative spacing as under service conditions and according to the manufacturer's instructions.

5.2.2 Method

The wet test method is as described in IEC 60060-1:2010, 4.4, and shall be carried out at ambient temperature, unless otherwise specified.

5.3 Test in water for stop ends

5.3.1 Installation

The stop ends shall be installed in a water tank of such dimensions as to have a height of water of 1,00 $^{+0,1}_{0}$ m over their top surface, unless otherwise specified. The water shall be at ambient temperature.

5.3.2 Method

The procedure for voltage application shall be as specified in IEC 60060-1:2010, 6.2, unless otherwise specified.

After the AC voltage withstand, the insulation resistance shall be measured between the screen and water. The DC test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case, not less than 1 min and not more than 5 min.

6 DC voltage tests

6.1 Installation

The set(s) of accessories shall be erected with all associated metalwork and fittings. The accessories shall be clean and dry before applying the test voltage.

6.2 Method

A voltage of negative polarity shall be applied to the cable conductor.

The test shall be made at ambient temperature and the procedure for voltage application shall be as specified in IEC 60060-1:2010, Clause 5.

7 Impulse voltage tests

7.1 Installation

For preparation of the test installation, involving metal enclosures and terminal boxes, reference shall be made to the relevant standard.

The three phases of the three-core accessories can be tested together, unless the spaces between each phase are specified. In this case (such as three single-core terminations in an enclosure), each phase of the three-core accessories shall be tested at a time, with the other two phases earthed.

7.2 Method

The test shall be conducted according to the procedure given in IEC 60230:2018, Clause 5, Clause 6, Clause 7, Clause 9 and Clause 10 and IEC 60230:2018/AMD1:2021, Clause 10, and shall be carried out at ambient temperature, unless otherwise specified.

7.3 Test at elevated temperature

The installation and the measurement of temperature are given in Clause 9.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of

– 5 K to 10 K above the maximum cable conductor temperature in normal operation for extruded insulation cables,
– 0 K to 5 K above the maximum cable conductor temperature in normal operation for paper insulated cables,

before and during the impulse test.

8 Partial discharge test

8.1 General

This test is only required for accessories for extruded insulation single-core cables and three-core cables with individually semi-conducting screened cores. It is not required for accessories incorporating paper insulated cables.

8.2 Method

The test shall be conducted in accordance with IEC 60270:2000 and IEC 60270:2000/AMD1:2015 and IEC 60885-2:1987[2] and shall be carried out at ambient temperature, unless otherwise specified.

The partial discharge shall be measured at the test voltage given in the relevant standard after maintaining the test object for 1 min at a pre-stressing voltage equal to the specified test voltage increased by 0,25 U_0.

8.3 Test at elevated temperature

The installation and the measurement of temperature are given in Clause 9.

2 Withdrawn.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of 5 K to 10 K above the maximum cable conductor temperature in normal operation, before and during the partial discharge test.

9 Tests at elevated temperature

9.1 Installation and connection

The accessories shall be erected, supported where necessary and provided with connections to permit heating current to be circulated.

Where terminations or separable connectors are to be tested, the connection between either lugs or bushings shall have an electrical cross-section equivalent to that of the cable conductor.

Where branch joints are to be tested, only the main cable shall carry the heating current.

Three-core accessories can be connected for either single-phase or three-phase heating current. When heated with single-phase current a single-phase voltage shall be superimposed on the heating current. Respectively when heated with three-phase current a three-phase voltage shall be superimposed on the heating current. In the case of a magnetic covering, a three-phase heating current shall be applied.

Accessories for belted cables shall be subjected to three-phase voltage.

9.2 Measurement of temperature

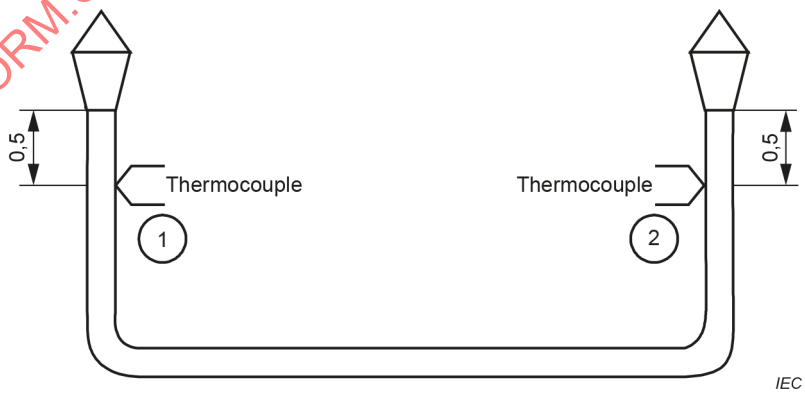
9.2.1 Cable conductor temperature

It is recommended that one of the methods described in Annex A is used to determine the actual conductor temperature.

9.2.2 Thermocouple position

If method 2 of Annex A is used to determine the conductor temperature, two thermocouples shall be attached to the cable sheath as shown in Figure 1 to Figure 6.

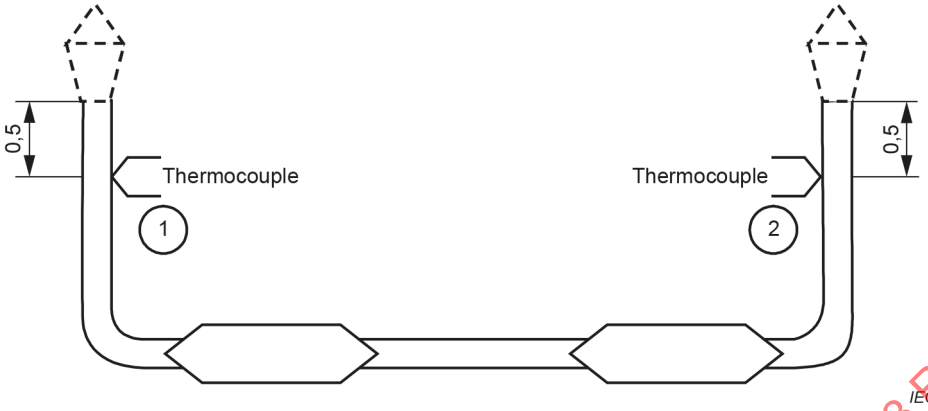
Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

Figure 1 – Terminations tested in air

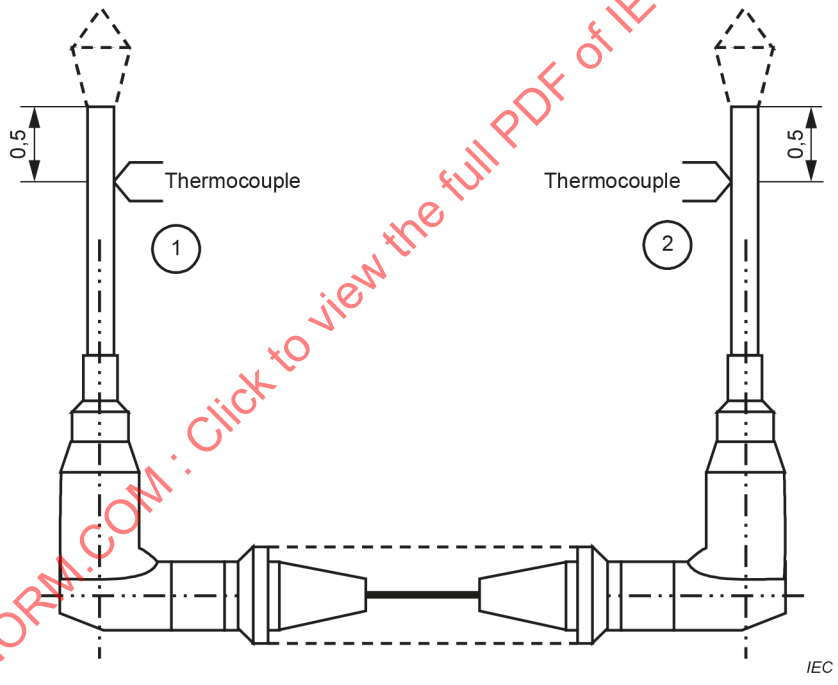
Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

Figure 2 – Joints tested in air

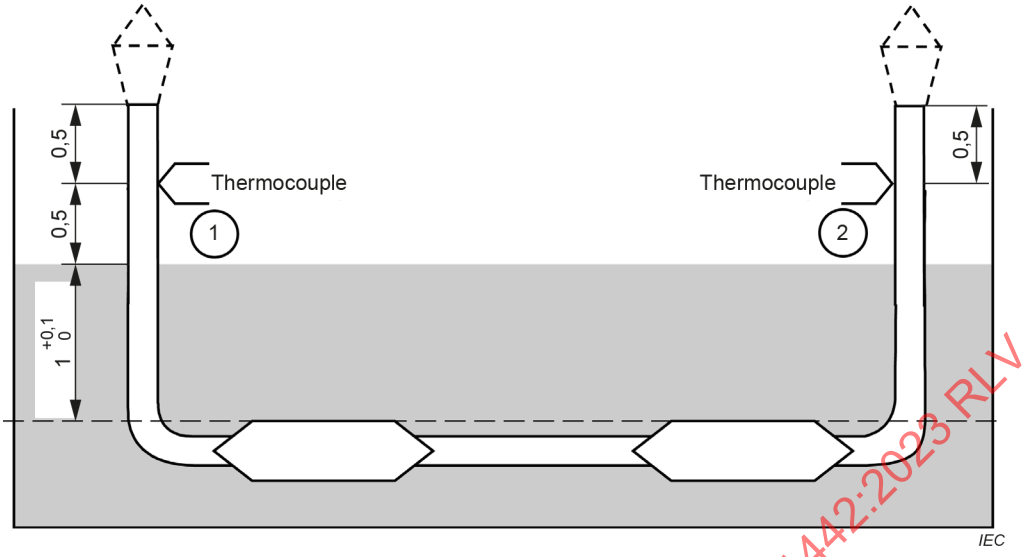
Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

Figure 3 – Separable connectors tested in air

Dimensions in metres

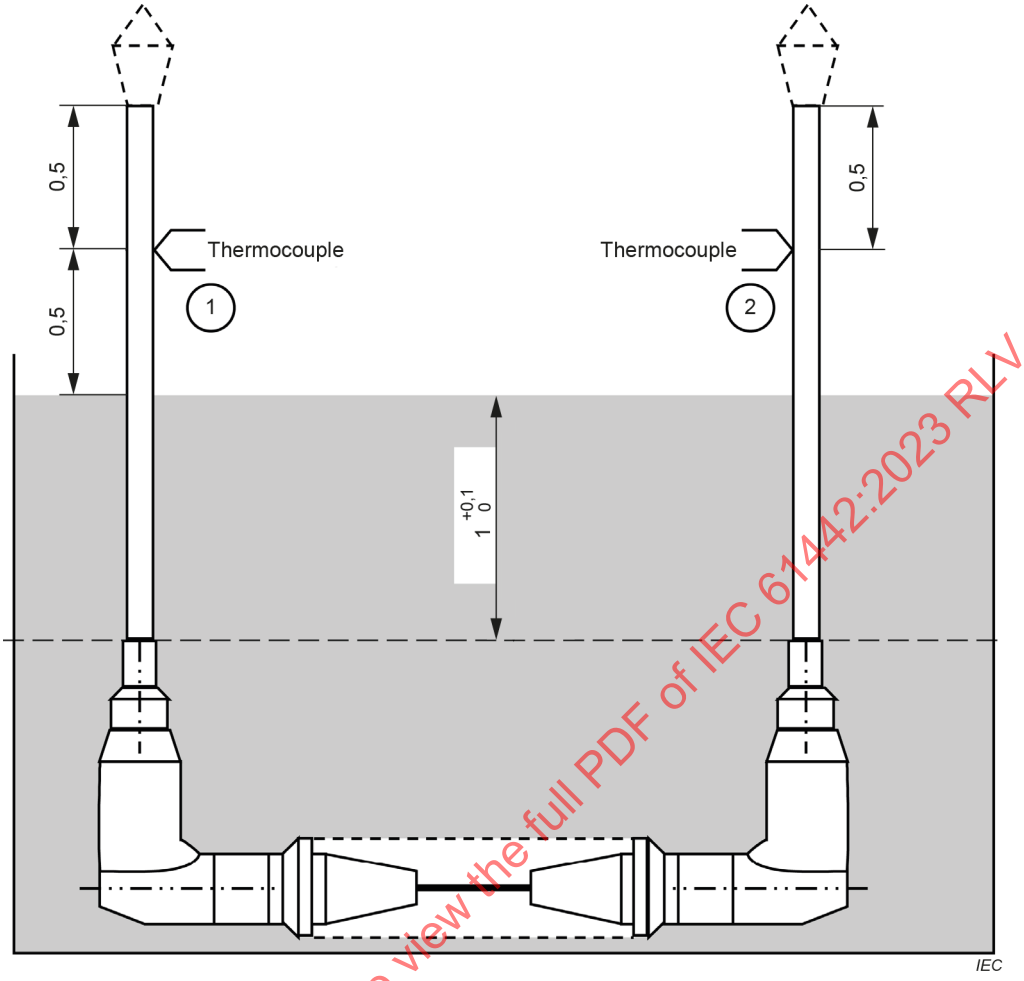


All distances mentioned to position thermocouples are minimum values.

NOTE The height of the water is as indicated, unless otherwise specified.

Figure 4 – Joints tested under water

Dimensions in metres

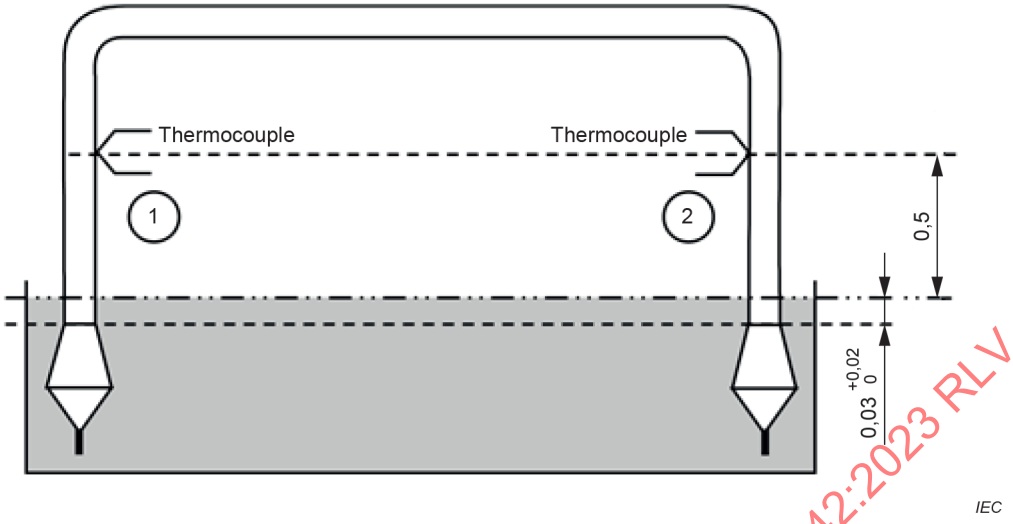


All distances mentioned to position thermocouples are minimum values.

NOTE The height of the water is as indicated, unless otherwise specified.

Figure 5 – Separable connectors tested under water

Dimensions in metres



All distances mentioned to position thermocouples are minimum values.

Figure 6 – Outdoor terminations tested under water

10 Heating cycle voltage test

10.1 Installation and method

The arrangement for tests in air or water shall be as given in Clause 9.

The measurement of temperature is also given in Clause 9.

Each heating cycle in air or water shall be of at least 8 h duration with at least 2 h at a steady temperature:

– 5 K to 10 K above the maximum cable conductor temperature in normal operation for cables with extruded insulation;
– 0 K to 5 K above the maximum cable conductor temperature in normal operation for paper insulated cables,

followed by at least 3 h of natural cooling to within 10 K of ambient temperature (see Figure 7).

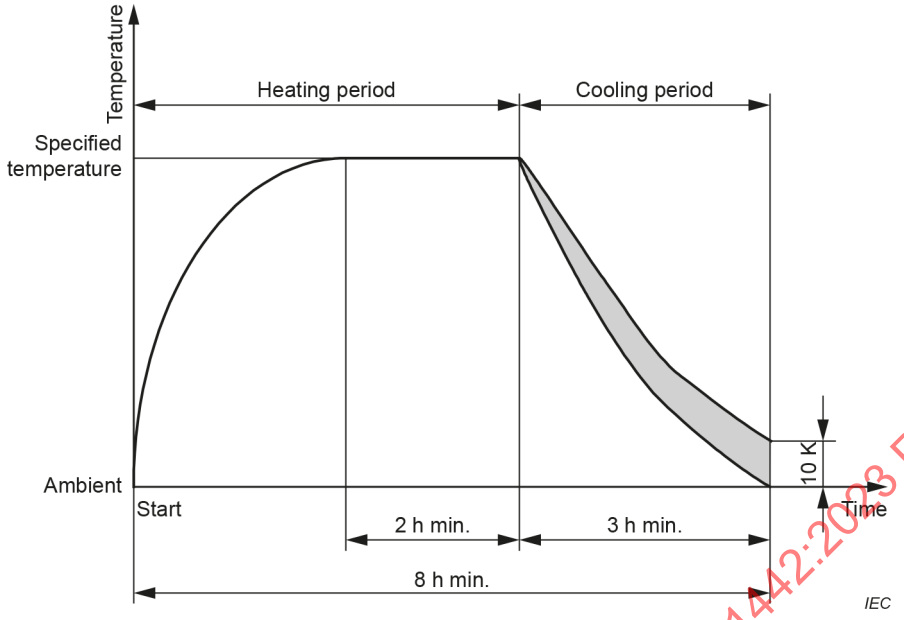


Figure 7 – Heating cycle

10.2 Test in air

The test assembly shall be subjected to the required number of heating cycles, energized at the voltage given in the relevant standard.

10.3 Test in water

For heat cycling in water, joints or separable connectors shall be installed in a vessel so as to have a height of water 1,00 $^{+0,1}_{0}$ m above the top surface of all accessories under test, unless otherwise specified. The water shall be at ambient temperature.

For accessories used with non-longitudinally water-blocked cable designs, the heating cycles voltage test under water shall be performed with oversheath damage. Expose the core(s) of one polymeric insulated cable at the entry to the accessory by removing an annulus of the oversheath, together with any bedding or filling material, of at least 50 mm in length, at a point which will be within the water and between 50 mm and 150 mm from the exterior of the accessory.

The exposure of the core(s) shall be made on the side with the shorter length between the oversheath cut and connectors.

NOTE The oversheath damage requirement does not apply to longitudinally water-blocked cable designs.

The test under water is not required for joints with a continuous metallic covering plumbed or welded to the cable metallic sheath.

The test assembly shall be subjected to the required number of thermal cycles, energized at the voltage given in the relevant standard.

After testing, the insulation resistance shall be measured between the conductor and metallic screen/sheath and the screen to water. The insulation resistance shall be measured between the screen and water only for cables without oversheath damage. The DC test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case, not less than 1 min and not more than 5 min.

10.4 Immersion test for outdoor terminations

10.4.1 Installation

All the terminations of a the test loop shall be immersed in water at ambient temperature with a height of water $0{,}03\ ^{+0{,}02}_{0}$ m above every part of the terminations. The test loop shall be installed upside down in a water tank at ambient temperature, in such a way that the terminations are fully immersed in water, including the end of the sealing element (see Figure 6).

10.4.2 Method

The test loop shall be subjected to 10 cycles under the conditions given in 10.1. The test loop shall not be energized.

11 Thermal short-circuit test (screen)

11.1 Installation

The test loop shall consist of the cable with its accessories.

The screen connections at both ends of the test loop shall be disconnected from earth and connected to a short-circuit generator. Accessories equipped with external earthing devices shall have these connections included in the short-circuit test.

The thermocouples to measure the screen temperature should be installed at minimum 0,5 m from the termination as shown in Figure 1, Figure 2 and Figure 3.

11.2 Method

The current (I_{sc}) and duration (t) for the test shall be agreed between the manufacturer and the customer, taking into account the actual short-circuit conditions of the network and the cable design. The duration (t) and current (I_{sc}) of the short-circuit shall be (1 ± 0,5) s up to a maximum current of 25 kA, if not otherwise specified. If the required short-circuit current exceeds this value a longer duration ≤ 5 s with a current between 25 kA and 45 kA shall be used.

The installation and the measurement of the conductor temperature are given in Clause 9.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of

– 5 K to 10 K above the maximum cable conductor temperature in normal operation for cables with extruded insulation;
– 0 K to 5 K above the maximum cable conductor temperature in normal operation for paper insulated cables,

before carrying out the short-circuit test.

Before and after the short-circuits, the temperature of the screen shall be measured using thermocouples or any other suitable means. Measurement of the screen temperature is not necessary, if the time between the two stresses is longer than 1 h while continuing to apply heating current in the cable conductor.

Two short-circuits, corresponding to the current and time requirements agreed, shall then be applied to the screen. The achieved Joule integral (I^2t) shall be within 0 % and +10 % of the calculated integral value. Between the two short-circuits, the cable screen shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first short-circuit.

If the current is not constant during the short-circuit, it is recommended to determine the RMS value of the short-circuit current using IEC 61238-1-3:2018, Annex E.

12 Thermal short-circuit test (conductor)

12.1 Installation

The test loop shall consist of the cable with its accessories.

Three-core accessories shall be tested with one end of the cable loop connected to the short-circuit generator and the other to a short-circuiting bar as described in the relevant standard. Alternatively, the three cores may be connected in series and tested as single-core accessories.

12.2 Method

The short-circuit method shall follow IEC 61238-1-3:2018, 6.4.1 and 6.4.2 with the following adjustment:

– The tests shall be carried out on the test loop at ambient temperature.

– Two short-circuits shall be applied using either alternating current or direct current.

Between the two short-circuits, the test loop shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first short-circuit (θ_i). An alternative method to avoid having to measure the conductor temperature prior to the second short-circuit is to ensure that the test sample has cooled for > 3 h. If a cooling duration of > 3 h is applied, the I^2t of the first short-circuit applies also for the second short-circuit.

The maximum permissible short-circuit temperature of the cable conductor is given in IEC 60949:1988 and IEC 60949:1988/AMD1:2008.

The following formulae from IEC 60949:1988 and IEC 60949:1988/AMD1:2008 shall be used:

For aluminium conductors: $$I^2t = 2{,}19 \times 10^4 \times S^2 \times \ln\left(\frac{\theta_{sc} + 228}{\theta_i + 228}\right)$$

For copper conductors: $$I^2t = 5{,}11 \times 10^4 \times S^2 \times \ln\left(\frac{\theta_{sc} + 234{,}5}{\theta_i + 234{,}5}\right)$$

where

I is the RMS value of the short-circuit current (A);

t is the duration (s);

S is the conductor cross-sectional area (mm^2);

θ_{sc} is the permissible short-circuit conductor temperature (°C);

θ_i is the conductor temperature at the start of the test (°C);

ln is the $\log_e$.

If the current is not constant during the short-circuit, it is recommended to determine the RMS value of the short-circuit current using IEC 61238-1-3:2018, Annex E.

13 Dynamic short-circuit test

13.1 General

This test is a three-phase test required for single-core cable accessories designed for initial peak currents higher than 80 kA and for three-core cable accessories designed for initial peak currents higher than 63 kA.

13.2 Installation

The test loop shall consist of either three single-core cables or a three-core cable with accessories.

One end of the test cable loop shall be connected to the short-circuit generator and the other to a short-circuiting bar, as described in the relevant standard.

For terminations, separable connectors and joints, the cable and accessories clamping method and the spacing between the accessories shall be as recommended by the manufacturer and shall be recorded in the test report. In addition, single-core cable joints shall be tested in a trefoil configuration with oversheaths in contact, unless a spaced trefoil is specified in which case the spacings shall be recorded.

13.3 Method

The short-circuit current shall be applied for a minimum of 10 ms to ensure that the initial peak current, as specified in the relevant standard, is reached.

The waveform shall be recorded.

NOTE In practice, clearance times of the order of 60 ms can be expected. Exceeding this time can cause thermal problems with the cable or accessory.

14 Humidity and salt fog tests

14.1 Apparatus

A single- or three-phase AC voltage source is required. The maximum voltage drop at the high voltage side of the source shall be less than 5 % at 250 mA leakage current during the test.

A humidity test chamber shall be used, equipped with spray nozzles or other form of humidifier capable of discharging atomized water at a rate of (0,4 ± 0,1) l/h/m^3 volume. Throughout the test duration, the spray water conductivity shall be (70 ± 10) mS/m for humidity tests and (1 600 ± 200) mS/m for salt fog tests. The chamber shall be designed such that no water drips directly on the accessories during the test.

Guidance on the test chamber and on the spray equipment is given in Annex B.

14.2 Installation

The test accessories shall be installed in the humidity chamber with the accessories having the same orientation and relative spacing as installed in service, and according to the manufacturer's instructions.

Three unscreened separable connectors or three shrouded terminations shall be mounted in a test terminal box and subjected to a three-phase voltage.

The three-core terminations shall also be subjected to a three-phase voltage.

In the case of a compact installation of three single-core terminations, it is recommended to carry out the test with a three-phase voltage.

The phase(s) of the transformer shall be protected with an automatic tripping device, connected to the current measuring source, set to de-energize the circuit when a leakage current of (1,0 ± 0,1) A RMS flows in the high-voltage circuit for a period between 50 ms and 250 ms.

14.3 Method

The humidity chamber during the tests shall be at ambient temperature.

The duration and the voltage of the tests are given in the relevant standard.

Up to 5 % of the testing duration shall be permitted in breaks. Cleaning of the accessories or any other form of similar interference shall not be permitted during the test.

The accessories shall be photographed in colour in at least two opposite directions before commencement and after completion of the test. Photographs shall clearly show the condition of the leakage path.

The condition of the samples shall be noted at the end of the test.

The test results shall record the occurrence of any flashover, a description and photographs of the condition of the accessories, particularly any tracking, erosion or mechanical damage. This information shall be included in the test report.

15 Impact test at ambient temperature

The test shall be carried out on joints, transition-joints and branch-joints only.

Prior to impacting, the insulation resistance shall be measured between the conductor and the metallic screen/sheath. The DC test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case, not less than 1 min and not more than 5 min.

If more than one joint is included in the loop, provision shall be made for the insulation resistance of each joint to be measured separately.

The joint shall be placed on a hard base, for example a concrete slab or floor, and solidly supported in a box filled with sand up to the horizontal centre line of the accessory (see Figure 8).

A wedge shaped steel block of (4,00 ± 0,05) kg having a (90 ± 1)° angle with a (2 ± 0,4) mm radius impacting edge shall be dropped freely from a height of (1,0 ± 0,01) m onto the joint so that the impacting edge is horizontal and at right angles to the axis of the joint. There shall be one impact at each end of the joint and one impact at a position over the conductor connectors. The impact at the end of the joint shall be at the oversheath cut in the case of an extruded insulation cable and at the metallic sheath cut in the case of a metallic sheathed cable.

After the impact test, the joint shall be immersed in water at ambient temperature with a height of water $1{,}00\ ^{+0,1}_{0}$ m over the top surface of the joint for a minimum of 3 h. The insulation resistance shall then again be measured as specified above between the conductor and the metallic screen/sheath and between the metallic screen/sheath (if insulated) and the water.

Details of visible effects and position of the impacts on the joint shall be recorded by photographs in the test report.

Dimensions in millimetres

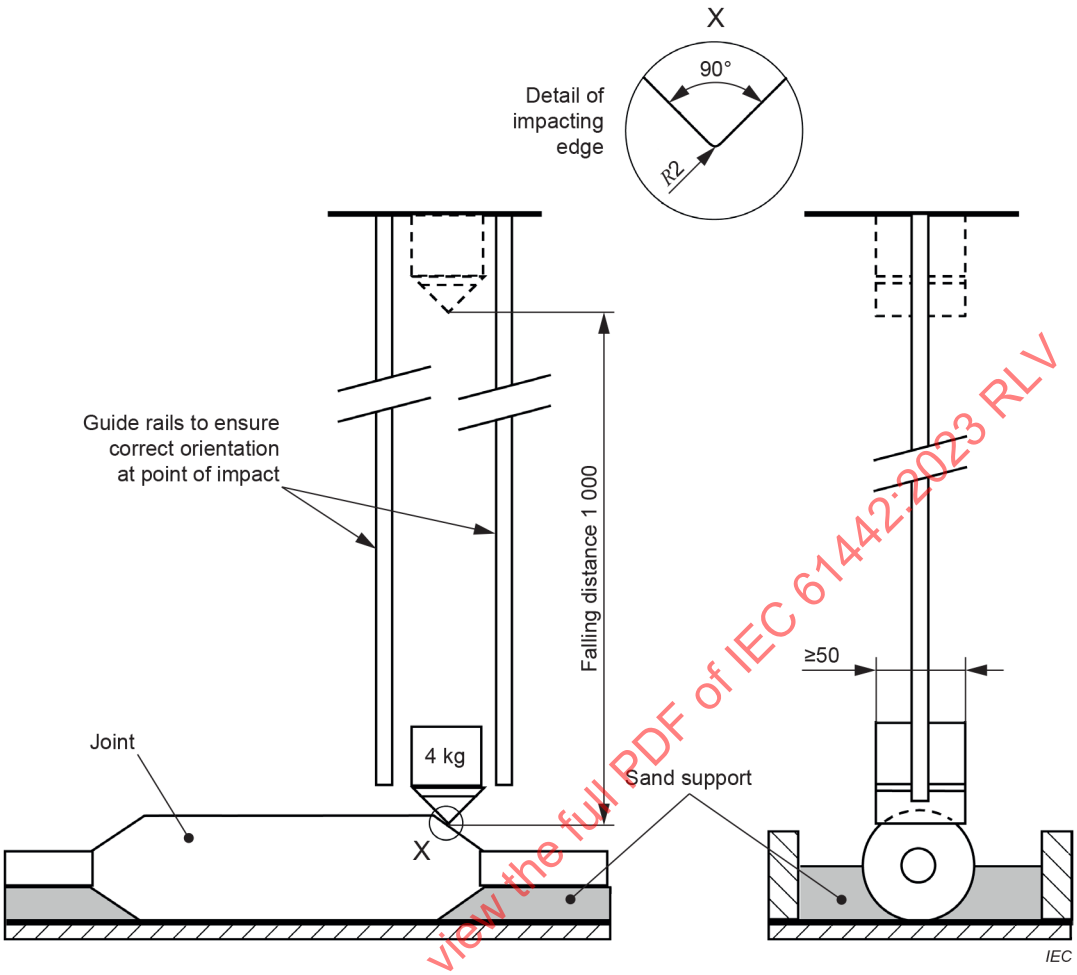


Figure 8 – Typical impact test apparatus for joints

16 Screen resistance measurement

16.1 General

The purpose of this test is to ensure that if a separable connector is touched by hand when it is in service, no electrical shock is experienced.

This test shall be carried out on separable connectors without a metallic housing or with a removable metallic housing. The metallic housing shall be removed prior to the test.

This test is not required for separable connectors which can only be used in service with the metallic housing in position.

16.2 Installation

The test shall be carried out on a separable connector which does not require to be installed on either a cable or a mating bushing. Silver painted or wraparound electrodes shall be installed at each end of the separable connector.

16.3 Method

The screen resistance of the separable connector shall be measured at ambient temperature between the two electrodes. The power dissipation of the test circuit shall not exceed 100 mW.

The sample shall then be subjected to thermal ageing in an air oven at (120 ± 2) °C for 168 h under the conditions described in IEC 60811-401:2012.

The separable connector screen resistance at ambient temperature shall be measured again as above.

17 Screen leakage current measurement

17.1 General

The purpose of this test is to ensure that if a separable connector is touched by hand when it is in service, no electrical shock is experienced.

This test is required for separable connectors without a metallic housing or with a removable metallic housing. The metallic housing shall be removed prior to the test.

This test is not required for separable connectors which can only be used in service with the metallic housing in position.

17.2 Installation

A separable connector shall be installed on a length of cable and connected to its mating bushing.

17.3 Method

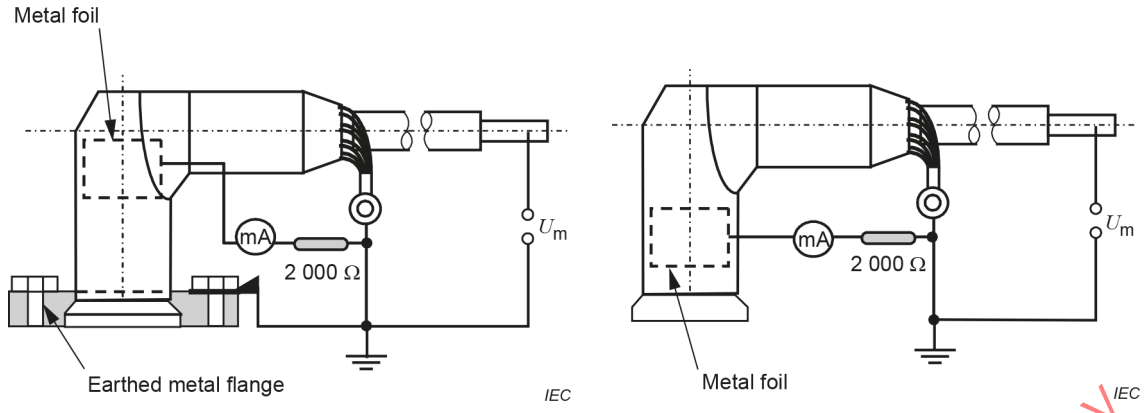
The test shall be carried out at ambient temperature.

A metal foil of 50 mm × 50 mm, shall be fixed without any air gap to the outer screen of the separable connector as far as possible from the earthing points:

– in the case of separable connectors with an earthed metal flange (see Figure 9 a)), the metal foil shall be placed mid-way between the metal flange and the earth bond of the cable screen;
– in the case of separable connectors without a metal flange (see Figure 9 b)), the metal foil shall be placed at the end of the separable connector opposite to the earth bond of the cable screen.

In both cases, the metal foil shall be earthed through a milliammeter and a resistance of 2 000 Ω, as shown in Figure 9.

The leakage current shall be measured with an AC test voltage of U_m applied between the conductor and earth.



a) With an earthed metal flange **b) Without an earthed metal flange**

Figure 9 – Test arrangement for the screen leakage current measurement

18 Screen fault current initiation test

18.1 General

The purpose of this test is:

a) in the case of a solidly earthed system or resistance earthed system, in which the first earth fault is cleared,

to demonstrate the ability of the separable connector screen to initiate a fault to earth which produces sufficient current to operate the circuit protection, should its insulation fail;

b) in the case of an unearthed or impedance earthed system, in which the first earth fault is held,

to demonstrate the ability of the separable connector screen to initiate and sustain a fault current to earth, should its insulation fail.

The test is applicable only to screened separable connectors and shall be carried out with the connectors installed as in service.

This test is required for separable connectors without a metallic housing or with a removable metallic housing. The metallic housing shall be removed prior to the test.

This test is not required for separable connectors which can only be used in service with the metallic housing in position.

18.2 Installation

A separable connector shall be assembled on a cable in accordance with the manufacturer's instructions. All parts of the separable connector which are normally earthed shall be connected to the cable screen, including the bushing screen.

For testing separable connectors used in solidly earthed systems, the faulting rod shall be of erosion resistant metal, (10 ± 0,5) mm in diameter and threaded at one end to engage the accessory metal connector through a drilled hole. The rod shall be in contact with the inner and outer screens and shall not protrude beyond the outer screen surface, as shown in Figure 10.

For separable connectors used in unearthed systems or impedance earthed systems, the faulting rod shall be replaced by a copper wire of approximately 0,2 mm in diameter. The wire shall be in contact with the inner and outer screens and shall not protrude beyond the outer screen surface, as shown in Figure 10.

18.3 Method

18.3.1 Solidly earthed system

The test shall be carried out at ambient temperature.

The circuit shall be adjusted to impose the separable connector phase-to-earth voltage U_0 on the test specimen and a short-circuit current of (10 ± 0,5) kA RMS. The test specimen shall be subjected to two tests that cause initiation of a fault current arc to earth, each operation having a minimum current flow duration of 0,2 s. Between the two tests, the test sample shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first test.

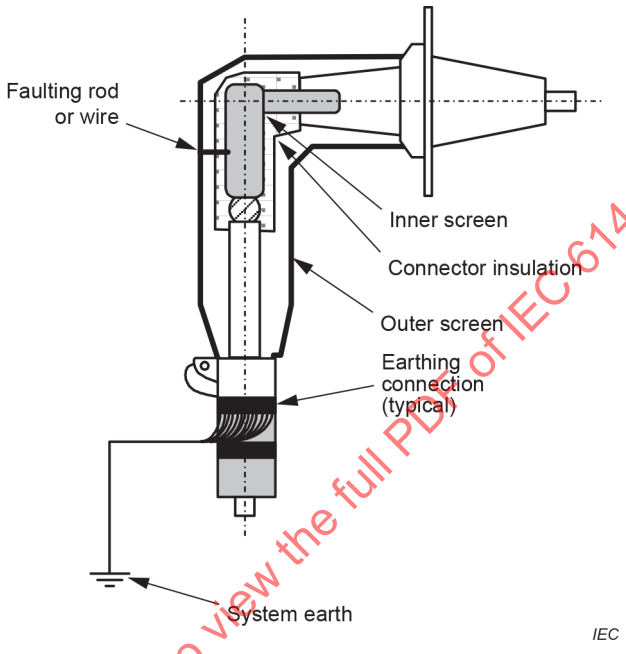


Figure 10 – Test arrangement for screen fault current initiation test

18.3.2 Unearthed or impedance earthed system

The test shall be carried out at ambient temperature.

The circuit shall be adjusted to impose the separable connector phase-to-earth voltage U_0 on the test specimen and a short-circuit current of at least 10 A RMS.

The current for the short-circuit test shall be agreed upon between the manufacturer and the customer, taking into account the actual short-circuit conditions of the network.

The test voltage and current shall be recorded continuously during the entire period. The sequence of the test shall be as follows:

a) voltage switched on for 1 s;
b) voltage switched off for 2 min;
c) voltage switched on for 2 min;
d) voltage switched off for 2 min;
e) voltage switched on for 1 min;
f) voltage switched off.

19 Operating force test

19.1 General

This test is only required for screened separable connectors equipped with a sliding contact.

19.2 Installation

A separable connector shall be assembled in accordance with the manufacturer's instructions and connected to its mating bushing, using the lubricant supplied by the manufacturer.

19.3 Method

The separable connector assembly shall be conditioned at (−20 ± 2) °C for at least 12 h. The test shall be carried out within 5 min after removal from the conditioning chamber. The separable connector shall be clamped by means of a suitable tool which allows operation along the axis of the separable connector and mating bushing interface.

A force shall be gradually applied to the separable connector in the axial direction. The force to open and close the separable connector and bushing interface shall be measured.

20 Operating eye test

20.1 General

This test is only required for screened separable connectors equipped with a sliding contact.

20.2 Installation

A separable connector shall be assembled on a cable loop in accordance with the manufacturer's instructions and connected to its mating bushing, using the lubricant supplied by the manufacturer. The separable connector shall be mechanically clamped along the interface.

20.3 Method

The test shall be carried out at ambient temperature.

A tensile force shall be gradually applied to the operating eye with a suitable tool in the direction of the bushing axis up to the specified force and maintained for the specified time as given in the relevant standard.

A rotational torque shall then be gradually applied, up to the specified value given in the relevant standard, using a suitable tool first in a clockwise direction and then in an anticlockwise direction.

21 Capacitive test point performance

21.1 General

This test is only required for screened separable connectors with a capacitive divider.

21.2 Installation

A separable connector shall be installed on a cable and the outer screen earthed in accordance with the manufacturer's instructions. It is not necessary for the separable connector to be connected to its mating bushing. It is recommended that the length of cable used be as short as possible.

21.3 Test method

Since the capacitances to be measured are very small, the use of a differential bridge is recommended in order to eliminate the influence of stray capacitances.

The following capacitances shall be measured at ambient temperature:

– C_{tc}: capacitance between the test point and the cable conductor;

– C_{te}: capacitance between the test point and the earth.

Annex A
(informative)

Determination of the cable conductor temperature

A.1 Purpose

For some of the accessory tests, it is necessary to raise the cable conductor to a given temperature, typically 5 K to 10 K above the maximum temperature in normal operation, while the cable is energized, either at power frequency or under impulse conditions. It is therefore not possible to have access to the conductor to enable the direct measurement of temperature.

In addition, the conductor temperature should be maintained within a restricted range (5 K), whereas the ambient temperature may vary over a wider range.

Thus, it is necessary to carry out a preliminary calibration on the test cable to determine the actual conductor temperature during the accessory tests, allowing for the permitted variation in ambient temperature.

Guidance is given hereafter on commonly used methods.

A.2 Calibration of the test cable conductor temperature

A.2.1 General

The purpose of the calibration is to determine the conductor temperature by direct measurement for a given current, within the temperature range required for the test.

The cable used for calibration should be identical to that to be used for the accessory test.

A.2.2 Installation of cable and thermocouples

The calibration should be performed on a minimum cable length of 2 m, the thermocouples being installed at 0,5 m from the cable ends, as shown in Figure A.1.

At each place, two thermocouples should be attached: one on the conductor (a), and one on the external surface (b), as shown in Figure A.2.

NOTE The thermocouples (b) on the external surface are only necessary if the method in A.3.3 is used.

It is recommended that the thermocouples are attached to the conductor by mechanical means since they can move due to vibrations of the cable conductor during heating.

If the actual test loop includes several individual cable lengths installed close to each other, these lengths will be subjected to thermal proximity effect. The calibration should therefore be carried out taking account of the actual test arrangement, measurements being performed on the hottest cable length (usually the middle length).

Dimensions in metres

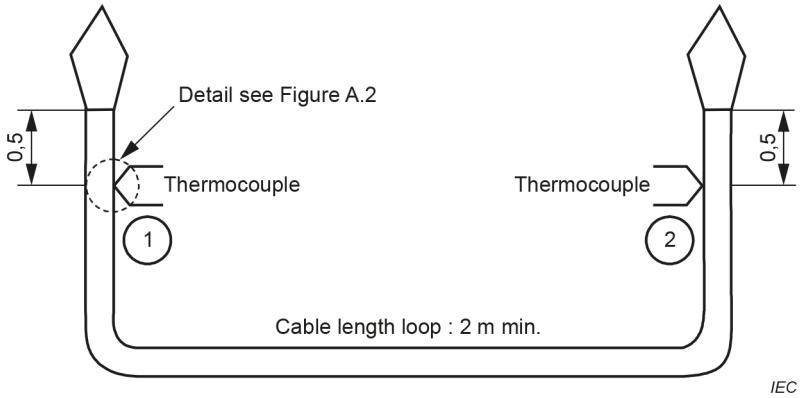
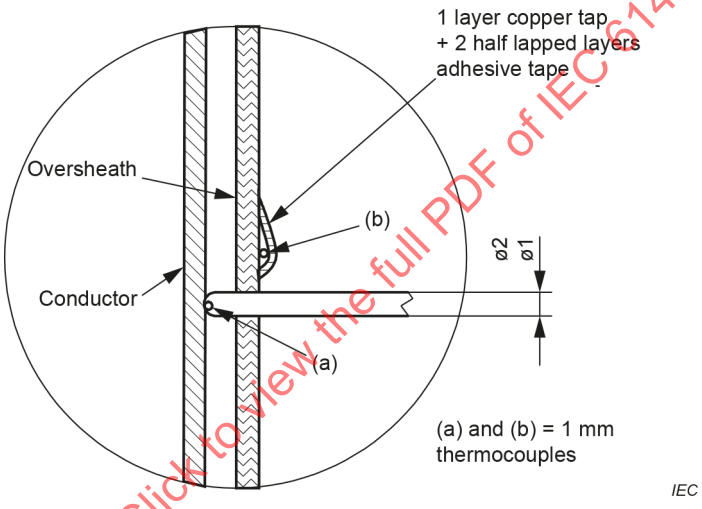


Figure A.1 – Reference cable

Dimensions in millimetres



NOTE Optionally the thermocouple can be welded to the copper tape at (b).

Figure A.2 – Arrangement of the thermocouples

A.2.3 Method

The calibration should be carried out in a draught free situation at a temperature between 5 °C and 35 °C.

Temperature recorders should be used to measure the conductor, sheath and ambient temperatures.

The cable should be heated until the conductor temperatures a_1 and a_2, indicated by thermocouples (a) at positions 1 and 2 of Figure A.1, have stabilized and reached the temperatures given below:

– between 5 K and 10 K above the maximum conductor temperature of the cable in normal operation, as given in the relevant standard for extruded insulation cables;
– between 0 K and 5 K above the maximum conductor temperature of the cable in normal operation, as given in the relevant standard for paper insulated cables.

It is considered that stabilization has been reached if the conductor temperatures, a_1 and a_2, do not show any variation larger than 2 K within a 2 h period.

When stabilization has been reached, the following should be noted:

– $\theta_{cond} = \frac{(a_1 + a_2)}{2}$;

– $\theta_{sheath.c} = \frac{(b_1 + b_2)}{2}$;

– $\theta_{amb.c}$;

– I_{cal};

where

θ_{cond} is the temperature of the conductor;

$\theta_{sheath.c}$ is the external temperature of the sheath during calibration;

$\theta_{amb.c}$ is the ambient temperature during calibration;

I_{cal} is the current during calibration.

A.3 Heating for accessory test

A.3.1 General

R_{20} is the resistance per unit length of conductor at 20 °C (see IEC 60228);

α_{20} is the temperature coefficient of resistance at 20 °C (see IEC 60228);

T is the thermal resistance between the conductor and the surrounding medium (including T_4, the thermal resistance of air);

T' is the thermal resistance between the conductor and the external surface of cable (excluding T_4, the thermal resistance of air).

NOTE According to the IEC 60287 series calculation methodology: $T' = T_1 + nT_2 + nT_3$

where

n = 1 for single-core cables;

n = 3 for three-core cables;

$T = T' + nT_4$.

$\theta_{amb.t}$ is the ambient temperature during the accessory test;

$\theta_{sheath.t}$ is the temperature of the external surface during the accessory test;

I_{test} is the current during the accessory test.

A.3.2 Method 1: Test based on measurement of ambient temperature

Assuming that dielectric, metallic sheath and armour losses are negligible:

– during the cable calibration:

$$\theta_{cond} - \theta_{amb.c} = R_{20} \times I^2_{cal} [1 + \alpha_{20} (\theta_{cond} - 20)]T \quad (A.1)$$

– during the accessory test:

$$\theta_{cond} - \theta_{amb.t} = R_{20} \times I^2_{test} [1 + \alpha_{20} (\theta_{cond} - 20)]T \quad (A.2)$$

(it is assumed that T, and particularly T_4, have not changed).

Combining Equations (A.1) and (A.2) gives:

$$I_{test} = I_{cal} \sqrt{\frac{\theta_{cond} - \theta_{amb.t}}{\theta_{cond} - \theta_{amb.c}}} \quad (A.3)$$

A.3.3 Method 2: Test based on measurement of the external surface temperature

– during the cable calibration:

$$\theta_{cond} - \theta_{sheath.c} = R_{20} \times I^2_{cal} [1 + \alpha_{20} (\theta_{cond} - 20)]T' \quad (A.4)$$

– during the accessory test:

$$\theta_{cond} - \theta_{sheath.t} = R_{20} \times I^2_{test} [1 + \alpha_{20} (\theta_{cond} - 20)]T' \quad (A.5)$$

Combining Equations (A.4) and (A.5) gives:

$$I_{test} = I_{cal} \sqrt{\frac{\theta_{cond} - \theta_{sheath.t}}{\theta_{cond} - \theta_{sheath.c}}} \quad (A.6)$$

It should be noted that Equation (A.4) allows the determination of the internal thermal resistance T' of the cable from readings of temperature and current.

Equation (A.5) can be written in the form:

$$\theta_{cond} = \frac{\theta_{sheath.t} + (1 - 20\,\alpha_{20})\,R_{20}\;I^2_{test}\;T'}{1 - \alpha_{20}\,R_{20}\;I^2_{test}\;T'} \quad (A.7)$$

It is therefore possible to transpose Formula (A.7) in the form of a chart, as shown in Figure A.3, giving θ_{cond} from $\theta_{sheath.t}$ readings, for various values of the heating current $I_{test\ 1}$, $I_{test\ 2}$, etc.

The use of such a chart is advisable if the test is not automatically controlled.

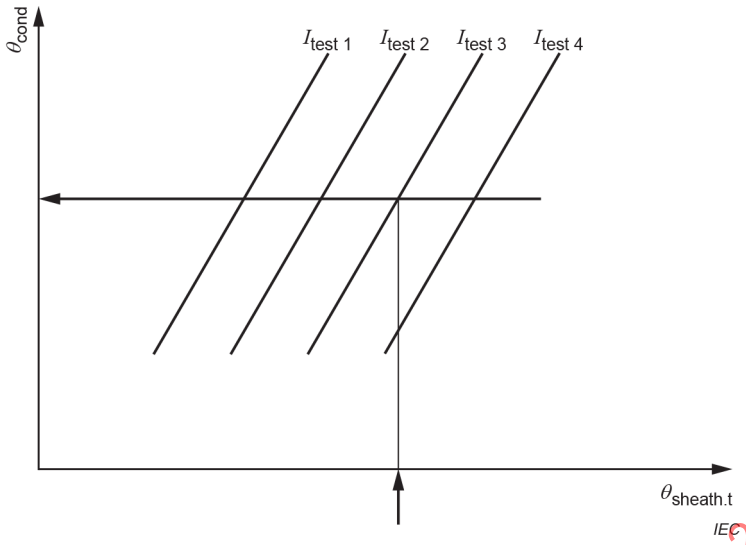


Figure A.3 – Current and temperatures curves

A.3.4 Method 3: Test using a control cable

In this method, a control cable identical to the cable used for the test is heated with the same current as the test loop. This cable is not energized and therefore thermocouples can be fitted to the conductor as recommended in A.2.2 above.

The test arrangement should be such that

– the control cable carries the same current as the test loop at any time,

– it is installed in such a way that mutual heating effects are taken into account throughout the test,

– for the test in water, the control cable remains in air in a draught free situation.

The thermocouples should be mounted on the external surface of the test loop at the positions given in Figure A.1, in the same way as the thermocouples are mounted on or under the surface of the control cable.

NOTE The temperatures measured with the thermocouples on the oversheath of the energized test loop and of the control cable, are used to check whether the oversheath of both test loops has the same temperature.

The temperature measured with the thermocouple fitted to the conductor of the control loop may be considered as representative for the conductor temperature of the energized test loop.

All thermocouples should be connected to a temperature recorder to enable temperature monitoring. The heating current of each test loop should be recorded to prove that the two currents are of the same value throughout the duration of the test. The difference between the heating currents should be kept within ±1 %.

The heating current is adjusted so that the conductor temperature is kept within the specified limits.

Annex B
(informative)

Details of the test chamber and spray equipment for humidity and salt fog tests

B.1 Test chamber

The dimensions of the test chamber should be adequate to contain the number of accessories being tested simultaneously, having due regard to the size of the accessory, the test voltage, safety clearances and stray electric fields, and the ratio of chamber volume to number of spray producing nozzles.

It should be constructed from corrosion resistant, waterproof materials. Temporary structures may be used. All high voltage bushings and support insulators should be mounted on earthed supports to ensure that an electric field does not exist along the surface of the chamber. The chamber should incorporate observation ports.

When the voltage supply (three-phase or single-phase, as appropriate) is introduced into the chamber through suitable bushings, such bushings should be well spaced to avoid interaction between adjacent phases. The length of the bushings within the test chamber should be designed with a long creepage length and deep undercuts in the skirt design to resist flashover.

A drain should be provided to conduct water out and away from the test chamber. The chamber should be so designed so as to prevent corrosion products or other contamination from dripping on the accessories during the test. The test chamber may be ventilated to prevent a build-up of pressure inside, but any such ventilation should not allow a significant amount of vapour or fog to escape to the atmosphere.

For the humidity and salt fog tests, means should be provided for measuring the rate of flow of solution into the atomizing sprays.

B.2 Spray equipment for humidity and salt fog tests

Humidity and salt fog tests may be conducted using the air nozzle spraying system described in IEC 60507. The equipment should be designed to run continuously for the duration of the test.

The nozzles should be set to blow fog into the test chamber. The fog should not be blown directly on the accessories but should fill the test chamber and circulate freely among the accessories by the action of fog and air currents. At least 80 % of the water ejected by the nozzles should be atomized into droplets not greater than 10 µm in diameter.

Alternatively, proprietary equipment is available for atomizing water and salt solution, which can be more convenient for the manufacturer conducting the tests. Use of such equipment should not be discouraged, but it is a pre-requisite that the manufacturer produces information showing that his equipment has the capacity to fill the test chamber adequately with the correct size of atomized water droplets.

B.3 High voltage transformers

For three-phase testing, a three-phase or three single-phase transformers should be used to energize the accessories under test. Single-phase transformers should be star-connected with the neutral point earthed. The voltage in the test circuit should remain stable and practically unaffected by varying leakage currents. The output voltage may be controlled by varying the low voltage supply to the transformers, and it should be possible to measure or calibrate the output voltage.

Bibliography

IEC 60055-1:1997, *Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV (with copper or aluminium conductors and excluding gas-pressure and oil-filled cables) – Part 1: Tests on cables and their accessories*
IEC 60055-1:1997/AMD1:2005

IEC 60228, *Conductors of insulated cables*

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

IEC 60502-2, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60507:2013, *Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems*

IEC 60986:2000, *Short-circuit temperature limits of electric cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*
IEC 60986:2000/AMD1:2008

IEC 62475:2010, *High-current test techniques – Definitions and requirements for test currents and measuring systems*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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MÉTHODES D'ESSAIS DES ACCESSOIRES DE CÂBLES D'ÉNERGIE DE TENSIONS ASSIGNÉES DE 6 kV (U_m = 7,2 kV) À 30 kV (U_m = 36 kV)

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Cette troisième édition annule et remplace la deuxième édition parue en 2005. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) 4.6 – la possibilité de démarrer les essais immédiatement a été incluse;
b) 4.11 – des méthodes d'essais sur câbles à ceinture ont été incluses;
c) 5.3.2 et 10.3 – des informations sur les essais de résistance d'isolement ont été ajoutées;
d) 8.2 – une précontrainte avec légère augmentation de la tension d'essai avant l'application de l'essai de décharge partielle a été incluse;

e) 11.2 – l'essai des accessoires avec des dispositifs de mise à la terre externes ont été inclus;

f) 11.2 – la durée de court-circuit et les niveaux d'intensité maximaux, exprimés en kA, ont été ajoutés;

g) 11.2 – la mesure de la température n'est pas exigée si la durée entre courts-circuits est supérieure à 1 h.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
20/2108/FDIS	20/2132/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La version française de la norme n'a pas été soumise au vote.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

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MÉTHODES D'ESSAIS DES ACCESSOIRES DE CÂBLES D'ÉNERGIE DE TENSIONS ASSIGNÉES DE 6 kV (U_m = 7,2 kV) À 30 kV (U_m = 36 kV)

1 Domaine d'application

Le présent document définit les méthodes d'essais applicables aux essais de type des accessoires de câbles d'énergie de tensions assignées de 3,6/6 (7,2) kV à 18/30 (36) kV inclus. Les méthodes d'essais spécifiées dans le présent document s'appliquent aux accessoires pour câbles à isolant extrudé et pour câbles isolés au papier imprégné, conformément à l'IEC 60502- 2 et l'IEC 60055-1, respectivement.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60060-1:2010, *Technique des essais à haute tension – Partie 1: Définitions et exigences générales*

IEC 60230:2018, *Essais de choc des câbles et de leurs accessoires*
IEC 60230:2018/AMD1:2021

IEC 60270:2000, *Techniques des essais à haute tension – Mesures des décharges partielles*
IEC 60270:2000/AMD1:2015

IEC 60811-401:2012, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 401: Essais divers – Méthodes de vieillissement thermique – Vieillissement en étuve à air*
IEC 60811-401:2012/AMD1:2017

IEC 60885-2:1987[1], *Méthodes d'essais électriques pour les câbles électriques – Partie 2: Essais de décharges partielles*

IEC 61238-1-3:2018, *Raccords sertis et à serrage mécanique pour câbles d'énergie – Partie 1- 3: Méthodes et exigences d'essai relatives aux raccords sertis et à serrage mécanique pour câbles d'énergie de tensions assignées supérieures à 1 kV (U_m = 1,2 kV) jusqu'à 30 kV (U_m = 36 kV) soumis à essai sur des conducteurs non isolés*

IEC 60949:1988, *Calcul des courants de court-circuit admissibles au plan thermique, tenant compte des effets d'un échauffement non adiabatique*
IEC 60949:1988/AMD1:2008

[1] Supprimée.

3 Termes et définitions

Aucun terme n'est défini dans le présent document.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

4 Installations et conditions d'essais

4.1 Les méthodes d'essais décrites dans le présent document sont destinées aux essais de type.

4.2 Les montages d'essais et le nombre d'échantillons d'essais sont précisés dans la norme particulière.

4.3 Les conditions d'essai sont spécifiées de l'Article 5 à l'Article 21. Si elles ne le sont pas, celles spécifiées dans les normes particulières doivent être utilisées.

4.4 Les paramètres d'essais et les exigences figurent dans la norme applicable, sauf indication contraire.

4.5 Pour les jonctions mixtes (isolant extrudé à un autre isolant extrudé ou isolant extrudé à isolant au papier imprégné), les paramètres d'essais (tension et température d'âme) sont ceux du câble dont les caractéristiques assignées sont les plus faibles.

4.6 Sauf spécification contraire du fabricant, les essais peuvent débuter immédiatement après le montage des accessoires sur les boucles d'essais. L'intervalle de temps entre l'installation des accessoires et le début des essais doit être consigné dans le rapport d'essai.

4.7 Les écrans de câble et les armures éventuelles doivent être reliés et mis à la terre à une seule extrémité pour éviter les courants de circulation.

4.8 Toutes les parties d'un accessoire qui sont normalement mises à la terre doivent être reliées à l'écran du câble. Toutes les pièces métalliques utilisées comme support doivent également être mises à la terre.

4.9 La température ambiante doit être de (20 ± 15) °C.

4.10 L'eau du robinet doit être utilisée pour tous les essais effectués dans l'eau.

4.11 Essais sur des câbles à ceinture:

Lors de la réalisation des essais sous tension alternative et des essais de cycles thermiques sous tension, un système de courant et tension d'essai triphasés doit être utilisé.

Lors de la réalisation des essais sous tension continue et des essais de choc, la tension d'essai doit être appliquée sur une âme du câble; les deux autres âmes du câble et l'écran doivent être mis à la terre. Toutes les âmes du câble doivent être soumises à essai individuellement.

5 Essais sous tension alternative

5.1 Essai à sec pour tous les accessoires

5.1.1 Installation

L'ensemble ou les ensembles d'accessoires doivent être montés avec toutes les pièces métalliques et de raccordement associées. Les accessoires doivent être propres et secs avant l'application de la tension d'essai.

5.1.2 Méthode

L'essai doit être réalisé à la température ambiante et la procédure d'application de la tension doit être conforme à l'IEC 60060-1:2010, Article 6, sauf spécification contraire.

5.2 Essai sous pluie pour les extrémités extérieures

5.2.1 Installation

Les extrémités doivent être montées en position verticale sauf si elles sont destinées à être installées avec une orientation différente, avec l'espacement relatif conforme aux conditions d'exploitation et aux instructions du fabricant.

5.2.2 Méthode

La méthode de l'essai sous pluie est telle qu'elle est décrite dans l'IEC 60060-1:2010, 4.4, et doit être effectuée à la température ambiante, sauf spécification contraire.

5.3 Essai dans l'eau pour les bouts perdus

5.3.1 Installation

Les bouts perdus doivent être immergés dans un récipient d'eau de dimensions telles que la hauteur d'eau se situe à 1,00 $^{+0,1}_{0}$ m au-dessus de leur surface supérieure, sauf spécification contraire. L'eau doit être à la température ambiante.

5.3.2 Méthode

La procédure d'application de la tension doit être comme spécifié dans l'IEC 60060-1:2010, 6.2, sauf spécification contraire.

Après la tenue à la tension alternative, la résistance d'isolement doit être mesurée entre l'écran et l'eau. La tension d'essai continue doit être comprise entre 100 V et 1 000 V, et doit être appliquée pendant une durée suffisante pour obtenir une lecture raisonnablement stable, cette durée étant dans tous les cas supérieure ou égale à 1 min et inférieure ou égale à 5 min.

6 Essais sous tension continue

6.1 Installation

L'ensemble ou les ensembles d'accessoires doivent être montés avec toutes les pièces métalliques et de raccordement associées. Les accessoires doivent être propres et secs avant l'application de la tension d'essai.

6.2 Méthode

Une tension de polarité négative doit être appliquée sur l'âme du câble.

L'essai doit être réalisé à la température ambiante et la procédure d'application de la tension doit être telle que spécifiée dans l'IEC 60060-1:2010, Article 5.

7 Essais de tension de choc

7.1 Installation

Pour la préparation du montage d'essai comprenant des enveloppes métalliques et des coffrets d'extrémité, on doit se référer à la norme particulière.

Les trois phases des accessoires tripolaires peuvent être soumises à essai ensemble, sauf si les espaces entre chaque phase sont spécifiés. Dans ce cas (par exemple de trois extrémités unipolaires dans une enveloppe), l'essai doit être réalisé tour à tour sur chaque phase des accessoires tripolaires, les deux autres phases étant reliées à la terre.

7.2 Méthode

L'essai doit être réalisé conformément à la procédure donnée dans l'IEC 60230:2018, Article 5, Article 6, Article 7, Article 9 et Article 10 et dans l'IEC 60230:2018/AMD1:2021, Article 10, et doit être réalisé à la température ambiante, sauf spécification contraire.

7.3 Essai à température élevée

L'installation et la mesure de la température sont indiquées à l'Article 9.

L'âme du câble doit être chauffée et stabilisée pendant au moins 2 h à une température de:

– 5 K à 10 K au-dessus de la température maximale de l'âme du câble en service normal, pour les câbles à isolant extrudé;
– 0 K à 5 K au-dessus de la température maximale de l'âme du câble en service normal, pour les câbles isolés au papier imprégné;

avant et pendant l'exécution de l'essai de tension de choc.

8 Essai de décharges partielles

8.1 Généralités

Cet essai n'est exigé que pour les accessoires pour câbles unipolaires et tripolaires à enveloppe isolante extrudée comportant des écrans semiconducteurs individuels. Il n'est pas exigé pour les accessoires montés sur des câbles isolés au papier imprégné.

8.2 Méthode

L'essai doit être réalisé conformément à l'IEC 60270:2000, l'IEC 60270:2000/AMD1:2015 et l'IEC 60885-2:1987[2] et doit être réalisé à la température ambiante, sauf spécification contraire.

Les décharges partielles doivent être mesurées à la tension d'essai donnée dans la norme applicable après avoir maintenu l'objet en essai pendant 1 min à une tension de précontrainte égale à la tension d'essai spécifiée augmentée de 0,25 U_0.

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2 Supprimée.

8.3 Essai à température élevée

L'installation et la mesure de la température sont indiquées à l'Article 9.

L'âme du câble doit être chauffée et stabilisée pendant au moins 2 h à une température de 5 K à 10 K au-dessus de la température maximale de l'âme du câble en service normal, avant et pendant l'exécution de l'essai de décharges partielles.

9 Essais à température élevée

9.1 Installation et raccordement

Les accessoires doivent être montés, supportés si nécessaire, et équipés de raccordements permettant la circulation d'un courant de chauffage.

Lorsque des extrémités ou des connecteurs séparables sont soumis à essai, le raccordement entre les cosses d'extrémité ou les traversées doit avoir une section électrique équivalente à celle de l'âme du câble.

Lorsque des dérivations sont soumises à essai, le courant de chauffage ne doit circuler que dans le câble principal.

Le courant de chauffage dans les accessoires tripolaires peut être soit monophasé soit triphasé. Lorsque le courant de chauffage est monophasé, une tension monophasée doit être superposée au courant de chauffage. Et lorsque le courant de chauffage est triphasé, une tension triphasée doit être superposée au courant de chauffage. Dans le cas d'un revêtement magnétique, un courant de chauffage triphasé doit être appliqué.

Les accessoires pour câbles à ceinture doivent être soumis à une tension triphasée.

9.2 Mesure de la température

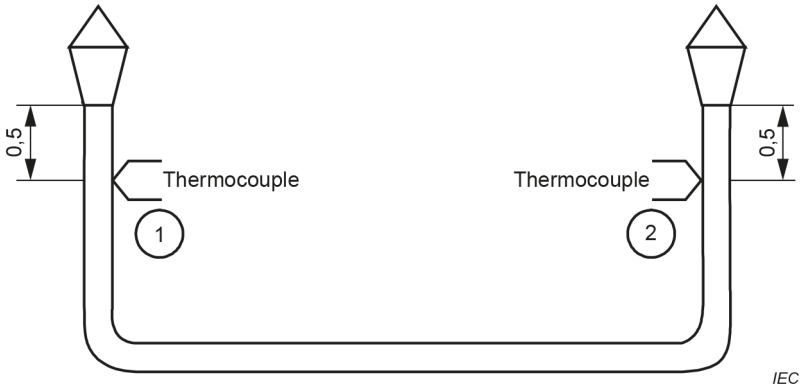
9.2.1 Température de l'âme du câble

Il est recommandé d'utiliser l'une des méthodes décrites à l'Annexe A pour déterminer la température réelle de l'âme.

9.2.2 Position des thermocouples

Si la méthode 2 de l'Annexe A est utilisée pour déterminer la température de l'âme, deux thermocouples doivent être fixés sur la gaine du câble comme représenté de la Figure 1 à la Figure 6.

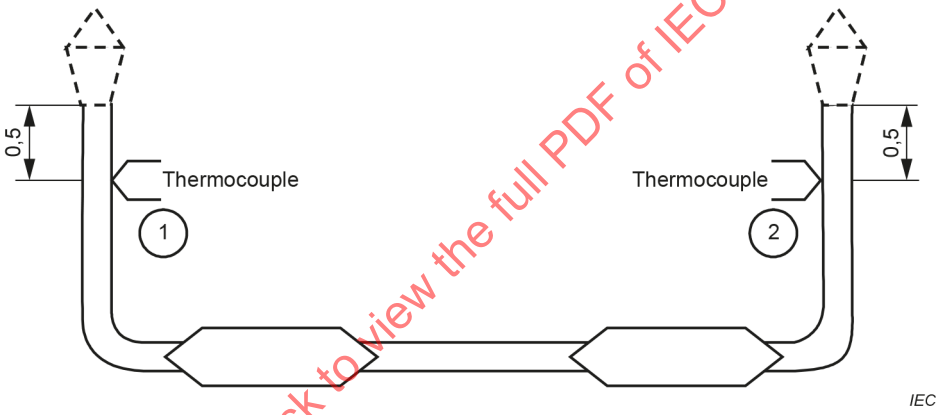
Dimensions en mètres



Toutes les distances mentionnées pour la position des thermocouples sont des valeurs minimales.

Figure 1 – Extrémités soumises à essai dans l'air

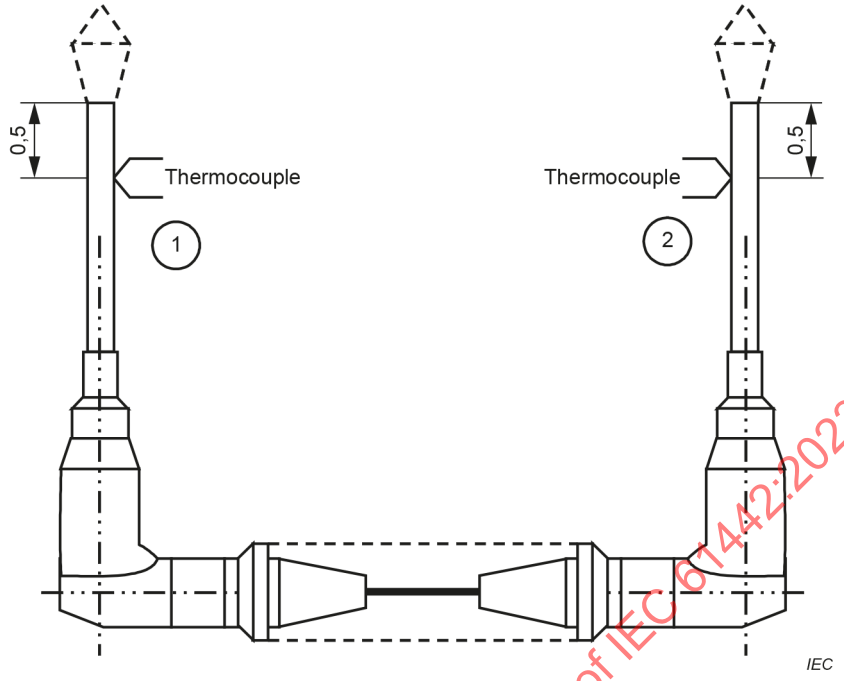
Dimensions en mètres



Toutes les distances mentionnées pour la position des thermocouples sont des valeurs minimales.

Figure 2 – Jonctions soumises à essai dans l'air

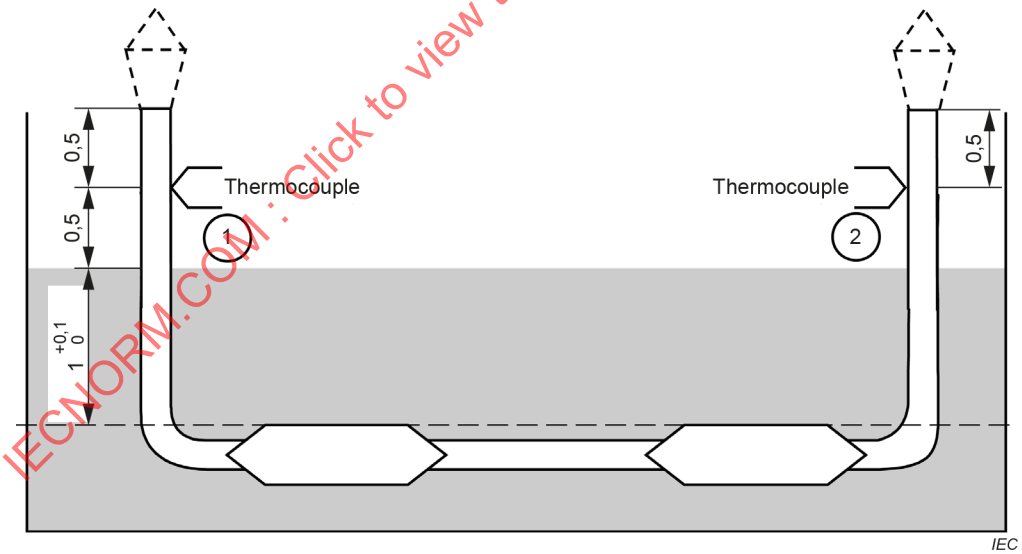
Dimensions en mètres



Toutes les distances mentionnées pour la position des thermocouples sont des valeurs minimales.

Figure 3 – Connecteurs séparables soumis à essai dans l'air

Dimensions en mètres

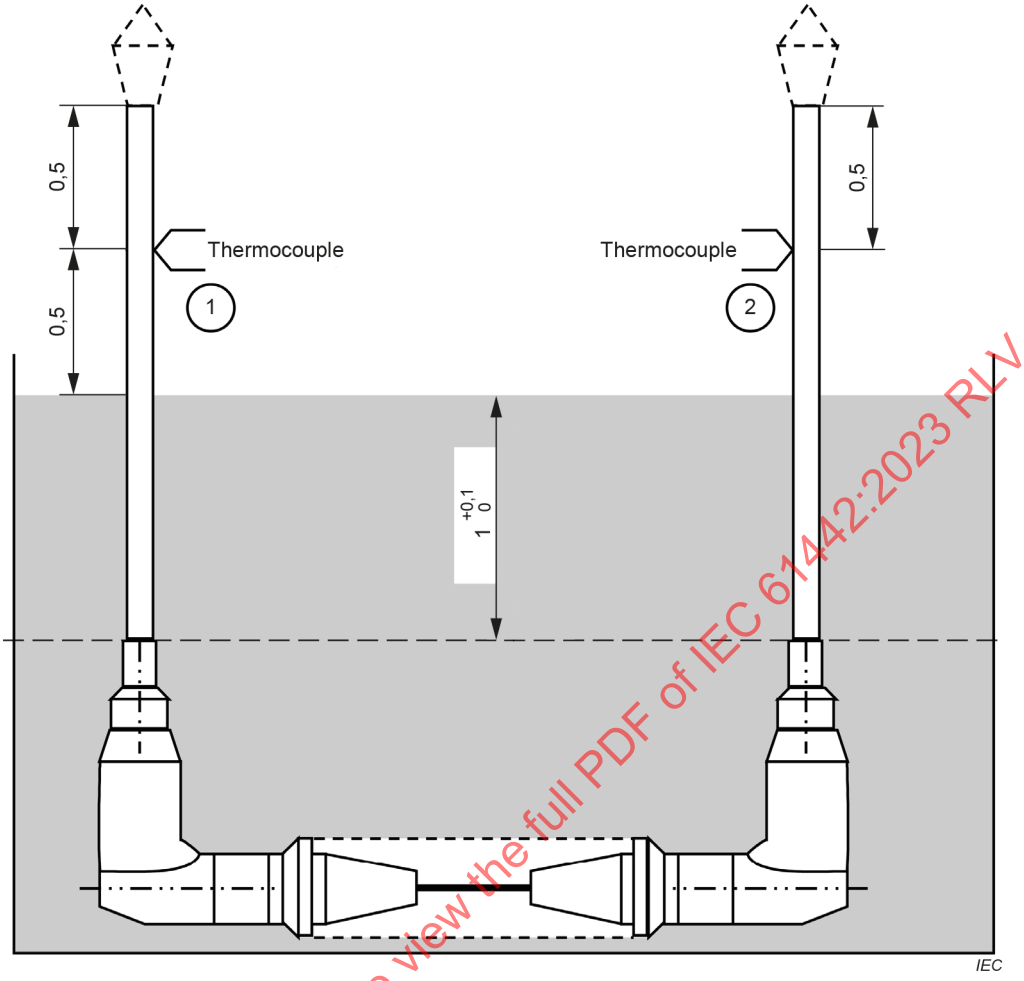


Toutes les distances mentionnées pour la position des thermocouples sont des valeurs minimales.

NOTE La hauteur d'eau est celle indiquée, sauf spécification contraire.

Figure 4 – Jonctions soumises à essai dans l'eau

Dimensions en mètres

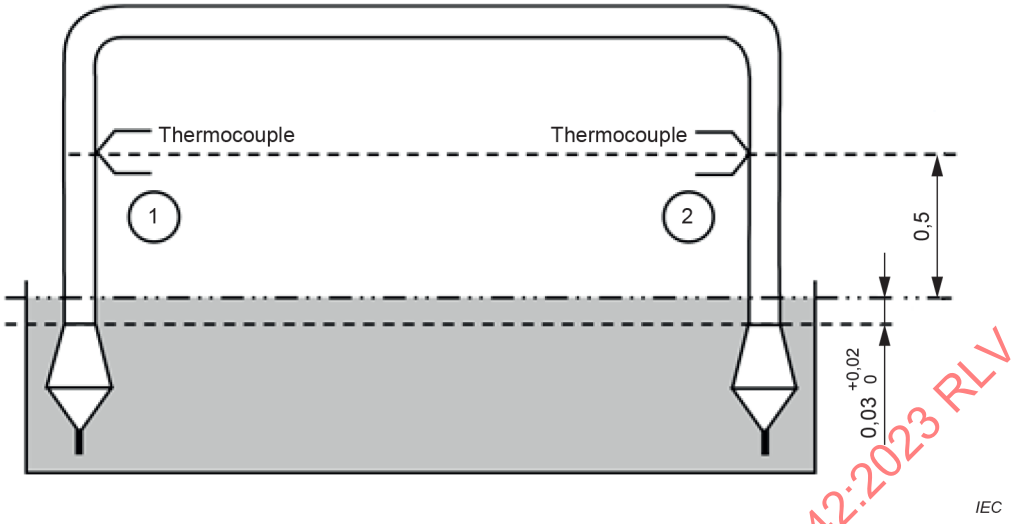


Toutes les distances mentionnées pour la position des thermocouples sont des valeurs minimales.

NOTE La hauteur d'eau est celle indiquée, sauf spécification contraire.

Figure 5 – Connecteurs séparables soumis à essai dans l'eau

Dimensions en mètres



Toutes les distances mentionnées pour la position des thermocouples sont des valeurs minimales.

Figure 6 – Extrémités extérieures soumises à essai dans l'eau

10 Essai de cycles thermiques sous tension

10.1 Installation et méthode

Le montage concernant les essais dans l'air ou dans l'eau doit être conforme à l'Article 9.

La mesure de la température est aussi indiquée à l'Article 9.

Chaque cycle thermique dans l'air ou dans l'eau doit durer au moins 8 h avec au moins 2 h de température constante:

– 5 K à 10 K au-dessus de la température maximale de l'âme du câble en service normal, pour les câbles à isolant extrudé;
– 0 K à 5 K au-dessus de la température maximale de l'âme du câble en service normal, pour les câbles isolés au papier imprégné;

suivies d'au moins 3 h de refroidissement naturel jusqu'à un maximum de 10 K au-dessus de la température ambiante (voir Figure 7).