BS EN 61442:2005

Test methods for accessories for power cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 36 kV (U_m = 42 kV)

The European Standard EN 61442:2005 has the status of a British Standard

ICS 19.080; 290.060.20

British Standards

National foreword

This British Standard is the official English language version of EN 61442:2005. It was derived by CENELEC from IEC 61442:2005. Together with BS EN 50393 (due for publication during 2005) it partially supersedes BS 7888-2:1998 which will be withdrawn on 1 July 2006.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags [C) (C]. Where a common modification has been introduced by amendment, the tags carry the number of the amendment. For example, the common modifications introduced by CENELEC amendment A11 are indicated by [C11) (C11].

The UK participation in its preparation was entrusted by Technical Committee GEL/20, Electric cables, to Subcommittee GEL/20/11, Cable accessories, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 31 and a back cover.

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 September 2005

ISBN 0 580 46194 7

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD **EN 61442**

NORME EUROPÉENNE

EUROPÄISCHE NORM April 2005

ICS 19.080; 290.060.20 Supersedes HD 628 S1:1996 + A1:2001

English version

Test methods for accessories for power cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 36 kV (U_m = 42 kV)
(IEC 61442:2005, modified)

Méthodes d'essais des accessoires de câbles d'énergie de tensions assignées de 6 kV (U_m = 7,2 kV) à 36 kV (U_m = 42 kV)
(CEI 61442:2005, modifiée)

Prüfverfahren für Starkstromkabelgarnituren mit einer Nennspannung von 6 kV (U_m = 7,2 kV) bis 36 kV (U_m = 42 kV)
(IEC 61442:2005, modifiziert)

This European Standard was approved by CENELEC on 2005-03-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 61442:2005 E

Foreword

The text of document 20/748/FDIS, future edition 2 of IEC 61442, prepared by IEC TC 20, Electric cables, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61442 on 2005-03-01.

A draft amendment, prepared by the Technical Committee CENELEC TC 20, Electric cables, was submitted to the formal vote and was approved by CENELEC for inclusion into EN 61442 on 2005-03-01.

This European Standard supersedes HD 628 S1:1996 + A1:2001.

In comparison with HD 628, the impact test at low temperature has been deleted.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2006-01-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2008-03-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61442:2005 was approved by CENELEC as a European Standard with agreed common modifications as given below.

COMMON MODIFICATIONS

Title

Amend the title to show the following upper voltage limit:

"… with rated voltages from 6 kV (U_m = 7,2 kV) up to 36 kV (U_m = 42 kV)"

1 Scope

Amend the voltage reference in paragraph 1 to read:

"… with rated voltages from 6 kV (U_m = 7,2 kV) up to 36 kV (U_m = 42 kV), …"

CONTENTS

TEST METHODS FOR ACCESSORIES FOR POWER CABLES WITH RATED VOLTAGES FROM 6 kV (U_m = 7,2 kV) UP TO 36 kV (U_m = 42 kV)

1 Scope

This International Standard specifies the test methods to be used for type testing accessories for power cables with rated voltages from [C› 6 kV (U_m = 7,2 kV) up to 36 kV (U_m = 42 kV). ‹C] Test methods are specified for accessories for extruded and paper insulated cables according to IEC 60502-2 and IEC 60055-1 respectively.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including 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, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60230:1966, *Impulse tests on cables and their accessories*

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

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 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)*

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*

3 Test installations and conditions

3.1 The test methods described in this standard are intended to be used for type tests.

3.2 Test arrangements and the number of test samples are given in the relevant standard.

3.3 The test conditions are specified in Clauses 4 to 20 of this standard. When they are not, they shall be as specified in the relevant standards.

3.4 Unless otherwise stated, the testing parameters and the requirements are given in the relevant standard.

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

3.6 The tests shall be started not less than 24 h after the installation of the accessories on the cable test loops, unless otherwise specified by the manufacturer. The time interval shall be recorded in the test report.

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

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

3.9 Ambient temperature shall be (20 ± 15) °C.

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

4 AC voltage tests

4.1 Dry test for all accessories

4.1.1 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.

4.1.2 Method

Unless otherwise specified, the test shall be made at ambient temperature, and the procedure for voltage application shall be as specified in Section 5 of IEC 60060-1.

4.2 Wet test for outdoor terminations

4.2.1 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 manufacturer's instructions.

4.2.2 Method

Unless otherwise specified, the wet test method is as described in 9.1 of IEC 60060-1, and shall be carried out at ambient temperature.

4.3 Test in water for stop ends

4.3.1 Installation

The stop ends shall be installed in a water tank of such dimensions as to have a height of water of $1{,}00\,^{+0{,}02}_{0}$ m over their top surface, unless otherwise specified. The water shall be at ambient temperature.

4.3.2 Method

Unless otherwise specified, the procedure for voltage application shall be as specified in IEC 60060-1.

5 DC voltage tests

5.1 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.

5.2 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 Section 4 of IEC 60060-1.

6 Impulse voltage tests

6.1 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.

6.2 Method

The test shall be conducted according to the procedure given in IEC 60230 (Clause 3 and following).

6.3 Test at elevated temperature

Installation and the measurement of temperature are given in Clause 8 of this standard.

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.

7 Partial discharge test

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.

7.1 Method

The test shall be conducted in accordance with IEC 60270 and IEC 60885-3.

The partial discharge shall be measured at the test voltage given in the relevant standard.

7.2 Test at elevated temperature

Installation and measurement of temperature are given in Clause 8 of this standard.

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.

8 Tests at elevated temperature

8.1 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 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. 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.

8.2 Measurement of temperature

8.2.1 Cable conductor temperature

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

8.2.2 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 Figures 1 to 6.

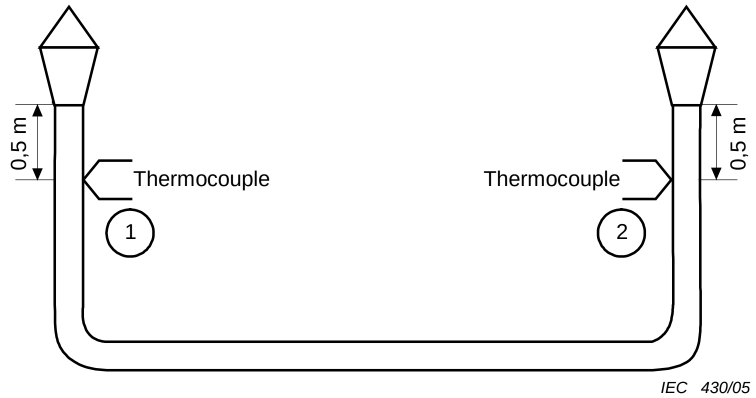

Figure 1 – Terminations tested in air

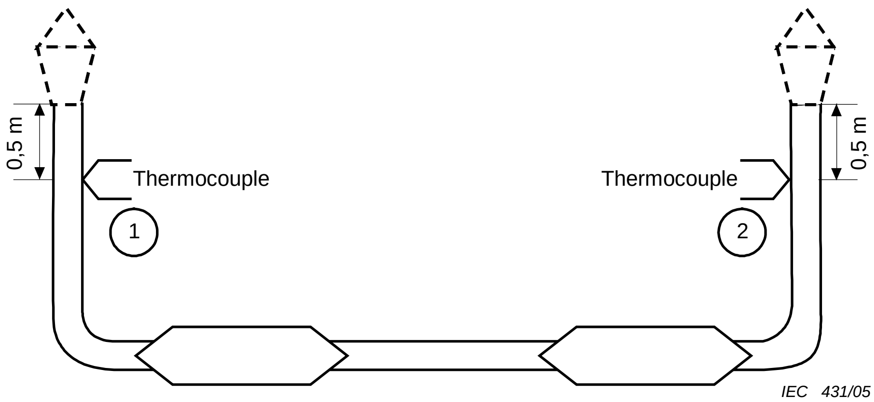

Figure 2 – Joints tested in air

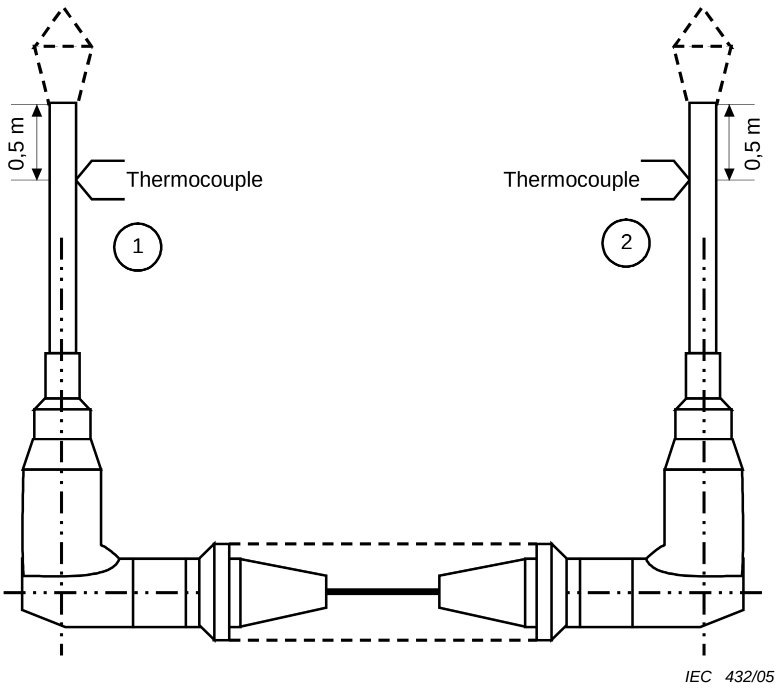

Figure 3 – Separable connectors tested in air

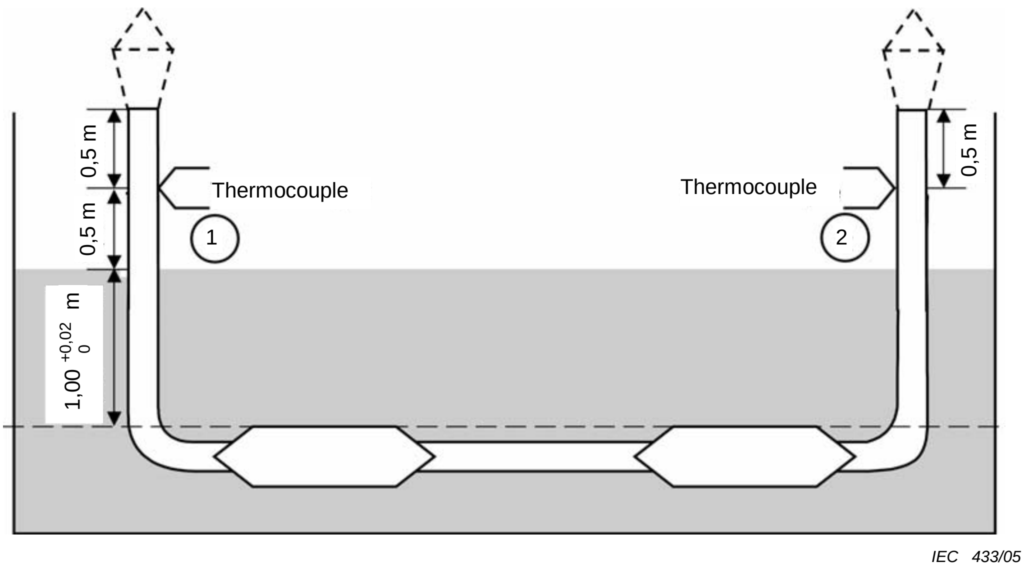

Figure 4 – Joints tested under water

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

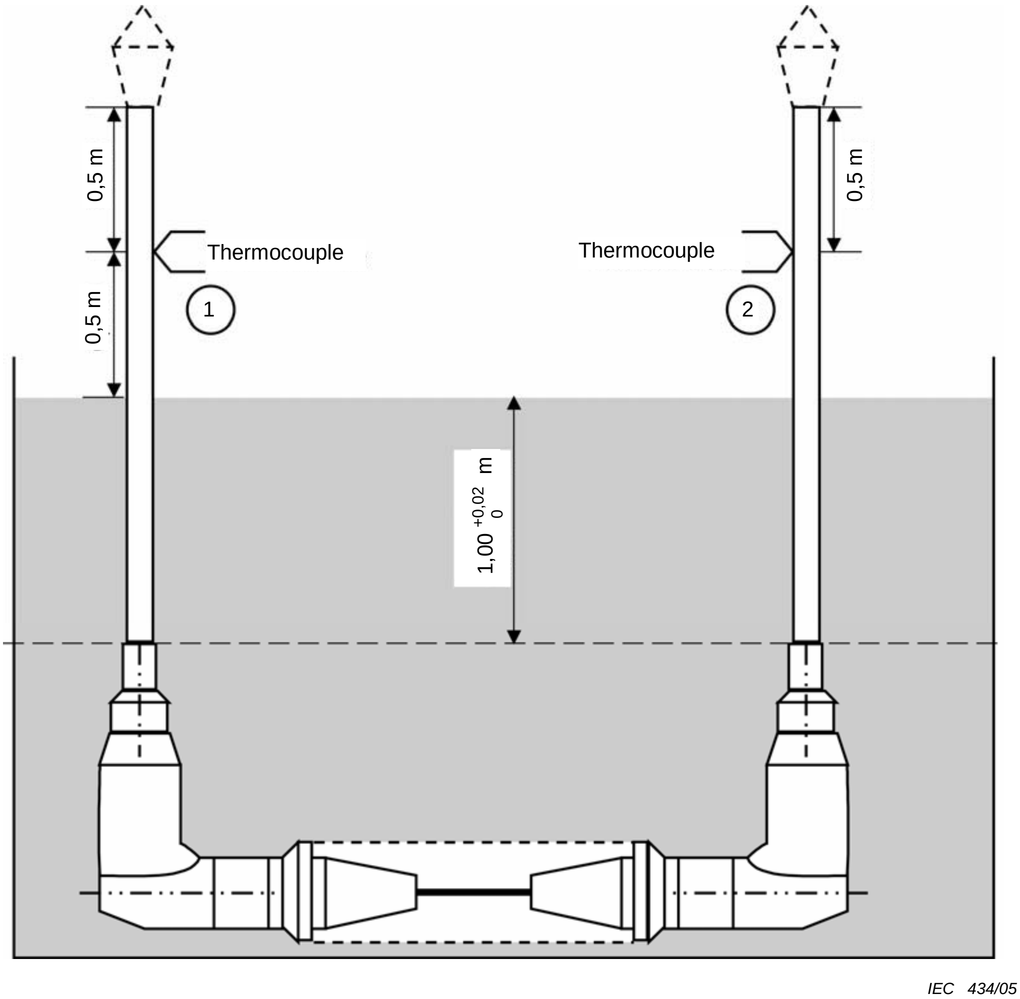

Figure 5 – Separable connectors tested under water

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

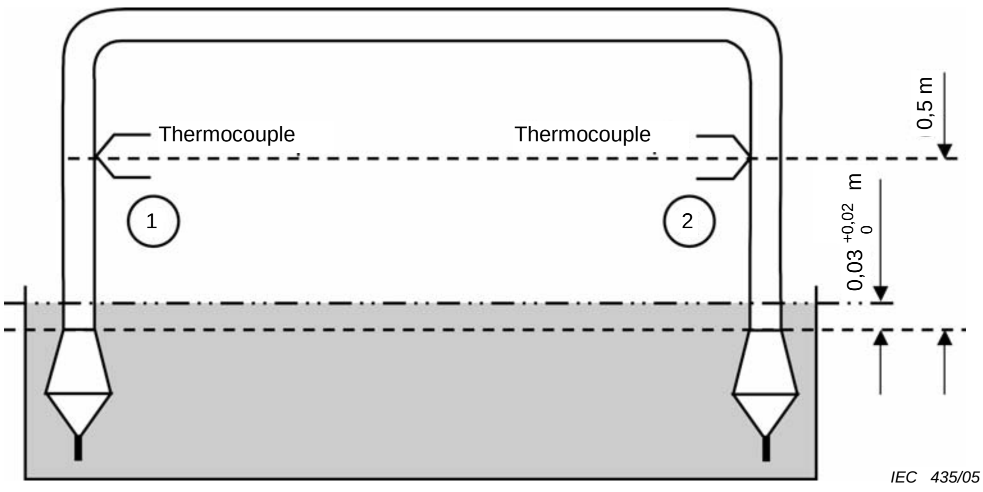

Figure 6 – Outdoor terminations tested under water

9 Heating cycles voltage test

9.1 Installation and method

The arrangement for tests in air or water shall be as given in Clause 8 of this standard.

Measurement of temperature is also given in Clause 8.

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 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).

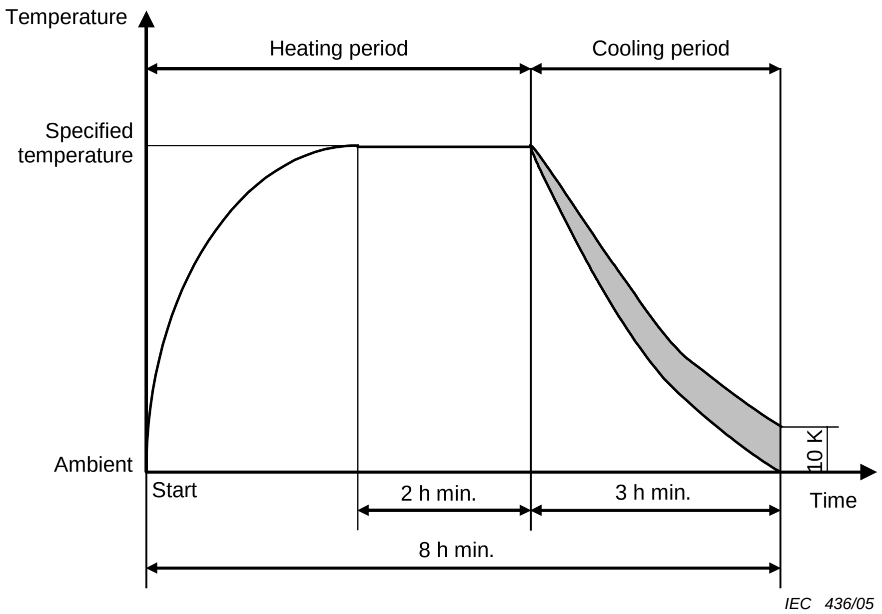

Figure 7 – Heating cycle

9.2 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.

9.3 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 $1{,}00^{+0{,}02}_{0}$ 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 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 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/ 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.

9.4 Immersion test for outdoor terminations

9.4.1 Installation

Two terminations of a 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 termination. 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).

9.4.2 Method

The test loop shall be subjected to 10 cycles under the conditions given in 9.1. The test loop shall not be energized.

10 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.

10.1 Installation

The test loop shall consist of cable with accessories.

The screen connections at both ends of the test loop shall be disconnected from earth and connected to a short-circuit generator.

10.2 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.

Installation and the measurement of conductor temperature are given in Clause 8.

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 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.

Two short-circuits, corresponding to the current and time requirements agreed, shall then be applied to the screen. 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.

11 Thermal short-circuit test (conductor)

11.1 Installation

The test loop shall consist of cable with 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.

11.2 Method

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

Two short-circuits shall be applied using either a.c. or d.c. 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).

The maximum permissible short-circuit temperature of the cable conductor is given in IEC 60986.

The following formulae from IEC 60986 shall be used:

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

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

where

I is the r.m.s. value of 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 start of test (°C);

ln is the $\log_e$.

If the current is not constant during the short-circuit, it is recommended to determine the r.m.s. value of the short-circuit current using Annex D of IEC 61238-1.

12 Dynamic short-circuit test

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

12.1 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.

12.2 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 be expected. Exceeding this time may cause thermal problems with the cable or accessory.

13 Humidity and salt fog tests

13.1 Apparatus

A single- or three-phase a.c. 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 is given in Annex B on the test chamber and on the spray equipment.

13.2 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 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.

Three-core terminations shall also be subjected to 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 r.m.s. flows in the high-voltage circuit for a period between 50 ms and 250 ms.

13.3 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 show clearly 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.

14 Impact test at ambient temperature

The test shall be carried out on joints only.

Prior to impacting, the insulation resistance shall be measured between the conductor and metallic screen/sheath. The d.c. 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 be made for the insulation resistance of each joint to be measured separately.

The joint shall be placed on a hard base, e.g. 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 kg having a 90° angle with a 2 mm radius impacting edge shall be dropped freely from a height of 1,0 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 $1{,}00\ ^{+0{,}02}_{-0}$ 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

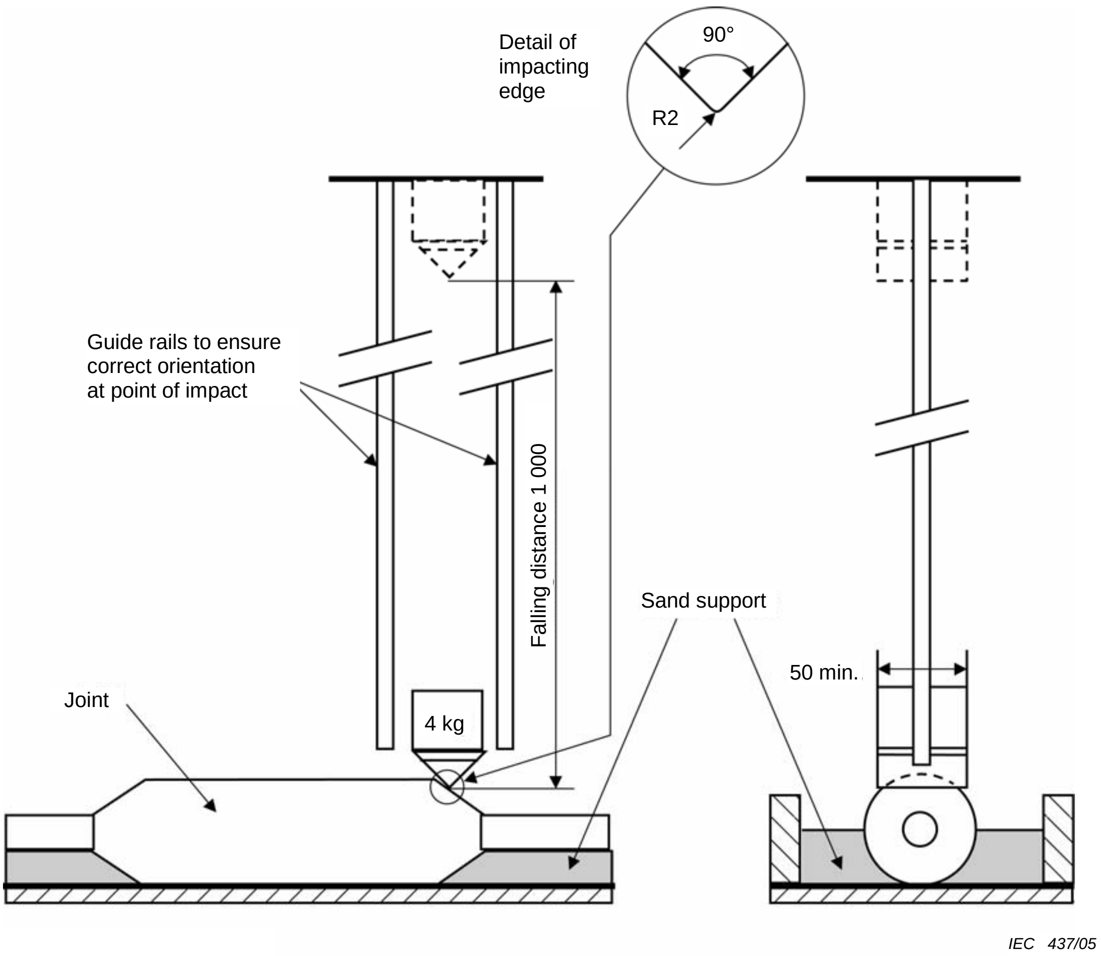

Figure 8 – Typical impact test apparatus for joints

15 Screen resistance measurement

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.

15.1 Installation

The test shall be carried out on a separable connector which does not need 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.

15.2 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.

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

16 Screen leakage current measurement

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.

16.1 Installation

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

16.2 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 9a), 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 9b), 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 a.c. test voltage of U_m applied between conductor and earth.

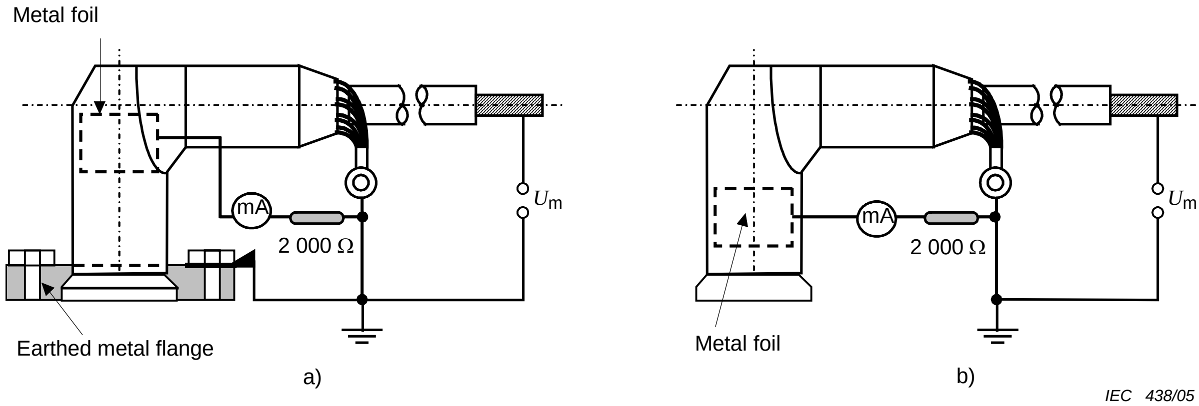

Figure 9 – Test arrangement for the screen leakage current measurement

17 Screen fault current initiation test

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.

17.1 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 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 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.

17.2 Method

17.2.1 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 kA r.m.s. 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.

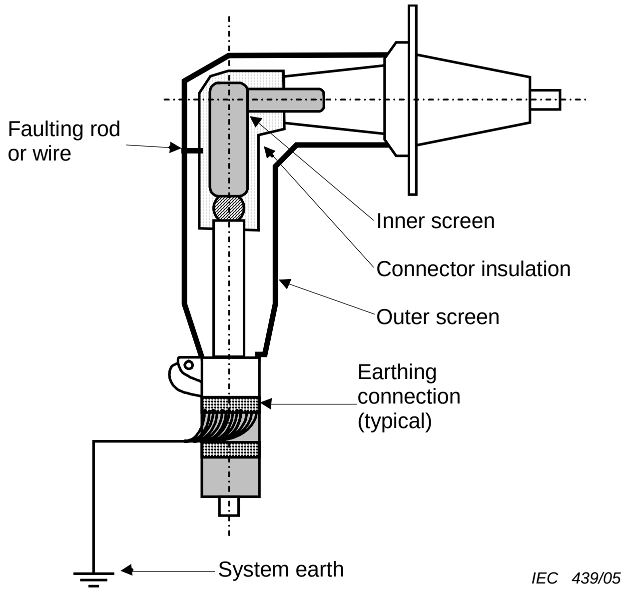

Figure 10 – Test arrangement for screen fault current initiation test

17.2.2 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.

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.

18 Operating force test

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

18.1 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.

18.2 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/bushing interface shall be measured.

19 Operating eye test

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

19.1 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.

19.2 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 anti-clockwise direction.

20 Capacitive test point performance

This test is only required for screened separable connectors.

20.1 Installation

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

20.2 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 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

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.2.1 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 method A.3.2 is used.

It is recommended that the thermocouples are attached to the conductor by mechanical means since they may 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).

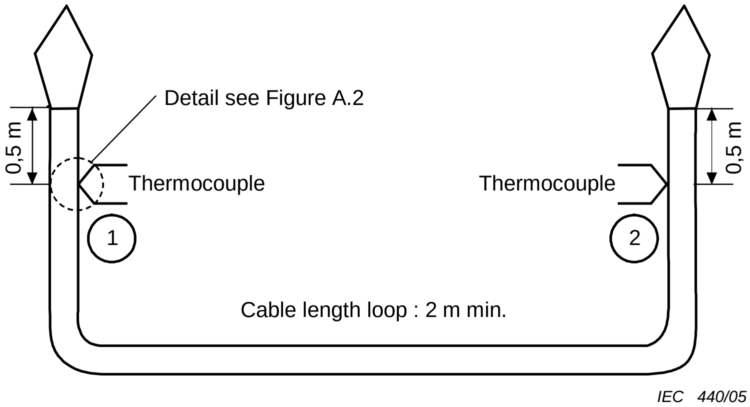

Figure A.1 – Reference cable

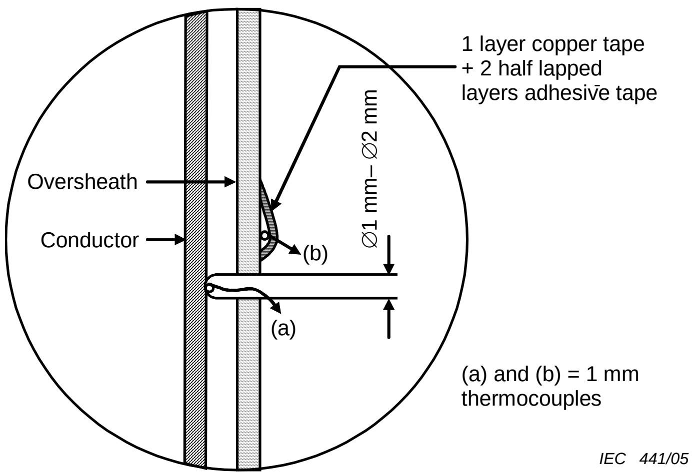

Figure A.2 – Arrangement of the thermocouples

A.2.2 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 $\theta_{cond} = \dfrac{(a_1 + a_2)}{2}$

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

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

– heating current l_{cal}

A.3 Heating for accessory test

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 IEC 60287: $T' = T_1 + nT_2 + nT_3$.

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 accessory test;

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

I_{test} is the current during accessory test.

A.3.1 Method 1: Test based on measurement of ambient temperature

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

– during cable calibration:

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

– during accessory test:

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

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

Combining (1) and (2) gives:

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

A.3.2 Method 2: Test based on measurement of the external surface temperature

– during cable calibration:

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

– during accessory test:

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

Combining (4) and (5) gives:

$$I\text{test} = I\text{cal} \sqrt{\frac{\theta_{cond} - \theta_{sheath.t}}{\theta_{cond} - \theta_{sheath.c}}} \qquad (6)$$

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

Equation (5) can be written in the form:

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

It is therefore possible to transpose this formula 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 $I_{test\ 1}$, $I_{test\ 2}$,....

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

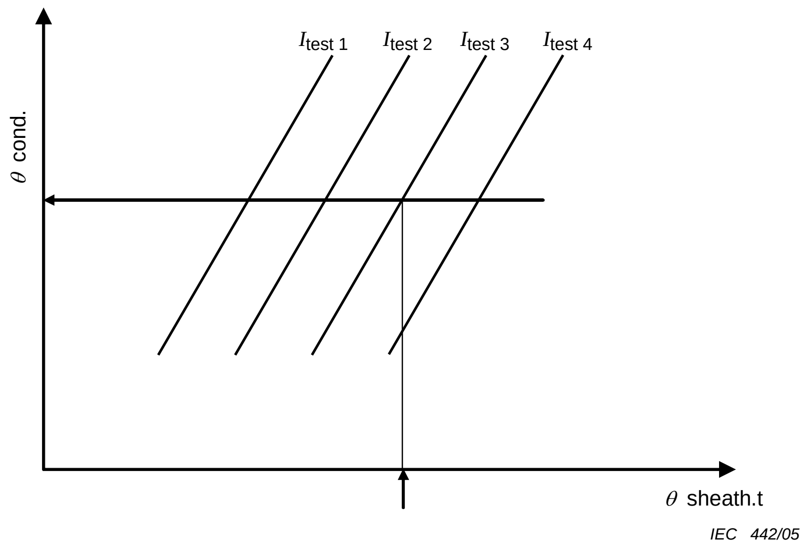

Figure A.3 – Current/temperatures curves

A.3.3 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.2.1 above.

The test arrangement should be such that

- the control cable should carry the same current as the test loop at any time,
- it should be installed in such a way that mutual heating effects are taken into account throughout the test.

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 temperature 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/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 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.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE Where an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60055-1	- [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 + corr. March	1989 1990	High-voltage test techniques Part 1: General definitions and test requirements	HD 588.1 S1	1991
IEC 60230	1966	Impulse tests on cables and their accessories	EN 60230	2002
IEC 60270	2000	High-voltage test techniques - Partial discharge measurements	EN 60270	2001
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	Insulating and sheathing materials of electric cables - Common test methods Part 1-2: General application - Thermal ageing methods	EN 60811-1-2 [2]	1995
IEC 60885-3	1988	Electrical test methods for electric cables Part 3: Test methods for partial discharge measurements on lengths of extruded power cables	EN 60885-3	2003
IEC 60986	2000	Short-circuit temperature limites of electric cables with rated voltagesf from 6 kV (U_m = 7,2 kV) up to 30 kV ($U_{m\,=}$ 36 kV)	-	-
IEC 61238-1 (mod)	2003	Compression and mechanical connectors for power cables for rated voltages up to 36 kV (U_m = 42 kV) Part 1: Test methods and requirements	EN 61238-1	2003

[1] Undated reference.

[2] EN 60811-1-2 includes corrigendum May 1988 + A1:1989 to IEC 60811-1-2:1985.

Bibliography

IEC 60228, *Conductors of insulated cables*

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

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

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