BS EN 50393:2015

BSI Standards Publication

Test methods and requirements for accessories for use on distribution cables of rated voltage 0,6/1,0 (1,2) kV

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National foreword

This British Standard is the UK implementation of EN 50393:2015. It supersedes BS EN 50393:2006, which will be withdrawn on 8 December, 2017.

The UK participation in its preparation was entrusted to Technical Committee GEL/20/11, Electric Cable accessories.

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

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English Version

Test methods and requirements for accessories for use on distribution cables of rated voltage 0,6/1,0 (1,2) kV

Méthodes et prescriptions d'essai pour les accessoires de câbles de distribution de tension assignée 0,6/1,0 (1,2) kV

Prüfverfahren und Prüfanforderungen für die Garnituren von Verteilerkabeln mit einer Nennspannung von 0,6/1,0 (1,2) kV

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Foreword

This document (EN 50393:2015) has been prepared by CLC/TC 20 “Electric cables”.

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-12-08
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2017-12-08

This document supersedes EN 50393:2006.

EN 50393:2015 includes the following significant technical changes with respect to EN 50393:2006:

– in Clause 1 'Scope', the revised statement referring to 'existing approvals' has been inserted;

– in Clause 3 'Definitions', definitions of stop end types have been revised to align with those of joints, and definitions of 'rigid' and 'non-rigid' joints have been removed;

– in Clause 6 'Range of compliance', the numbers of joint and termination test samples have been increased (see also Table 6), compliance restriction and extension with regard to different cable designs have been clarified, and compliance restrictions and extensions relating to conductor connectors have been inserted and shown in a new Table 2;

– in 7.3, Table 3, joints of Type II are subject to a new test involving 9 heating cycles in water without oversheath damage (see also 8.6.2);

– in 7.3, Tables 3, 4 and 5, the footnotes referring to examination of tested accessories have been removed;

– in Clause 8 'Test methods', the AC voltage withstand test procedure has been simplified and clarified, references to 'rigid' and 'non-rigid' joints have been removed, reference to the 9 cycle test for Type II joints (Table 3) has been inserted, and requirements relating to examination of tested joints have been simplified and references to specific technologies or materials have been removed;

– Annexes B, C and D have been added to assist in full and accurate identification of test cable, accessories and connectors for inclusion in test reports.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

1 Scope

This European Standard details the performance requirements and the test methods for type testing of cable accessories for use with power distribution cables of rated voltage 0,6/1,0 (1,2) kV as defined in HD 603 or other relevant cable standards.

Cable accessories covered by this European Standard include joints, stop ends and outdoor terminations for extruded solid dielectric insulated cables and transition joints between extruded solid dielectric insulated and impregnated paper insulated cables. Joints, stop ends and outdoor terminations for impregnated paper insulated cables are not included.

The service operating conditions of accessories should be compatible with the service operating conditions of cables on which they are to be installed.

Accessories for special applications such as submarine, shipboard, explosive or seismic environments, or where specified fire performance characteristics are required, are not included.

NOTE 1 This European Standard does not invalidate existing approvals of products achieved on the basis of national standards and specifications and/or the demonstration of satisfactory service performance. However, products approved according to such national standards or specifications cannot directly claim approval to this European standard.

NOTE 2 It may be possible, subject to agreement between supplier and purchaser, and/or the relevant conformity assessment body, to demonstrate that conformity to the earlier standard can be used to claim conformity to this European Standard, provided an assessment is made of any additional type testing that may need to be carried out. Any such additional testing that is part of a sequence of testing cannot be done separately.

2 Normative references

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

EN 61180-1:1994, *High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test and procedure requirements (IEC 61180-1:1992)*

EN 61238-1, *Compression and mechanical connectors for power cables for rated voltages up to 36 kV* (U_m *= 42 kV) – Part 1: Test methods and requirements (IEC 61238-1)*

HD 603, *Distribution cables of rated voltage 0,6/1 kV*

IEC 60050-461, *International Electrotechnical Vocabulary – Chapter 461: Electric cables*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-461 and the following apply.

3.1
joint
accessory suitable for use in air or underground which makes a connection between two or more insulated power cables to form a continuous circuit

3.2
type I joint
joint where impact withstand, impulse voltage withstand and metallic screen short-circuit current withstand tests are not required

3.3
type II joint
joint tested for impact withstand but not for impulse voltage withstand or metallic screen short-circuit current withstand

3.4
type III joint
joint tested for impulse voltage withstand and metallic screen short-circuit current withstand but not for impact withstand

3.5
transition joint
accessory making a connection between cables having extruded solid dielectric insulation and impregnated paper insulation

3.6
stop end
accessory providing a means of insulating the end of an energised cable

3.7
type I stop end
stop end where impact withstand and impulse voltage withstand tests are not required

3.8
type II stop end
stop end tested for impact withstand but not for impulse voltage withstand

3.9
type III stop end
stop end tested for impulse voltage withstand but not for impact withstand

3.10
cable crutch
position at which the laid up cores of a multicore cable separate into individual cores

3.11
outdoor termination
termination intended for use where it is directly exposed to either solar radiation or weathering or both

3.12
type I termination
termination where impulse voltage withstand is not required

3.13
type II termination
termination tested for impulse voltage withstand

3.14
connector
device to connect cable conductors together

3.15
compression (crimp) connector
connector in which electrical connection is made by deformation or reshaping of the barrel around the cable conductor

3.16
mechanical connector
connector in which electrical connection is made by pressure applied using screws or bolts

3.17
multi-polar connector
connector with the facility to connect conductors of two or more phases within one body and having electrical insulation between phases

3.18
IPC – Insulation Piercing Connector
connector in which electrical contact with the conductor is made by metallic protrusions which pierce the insulation of the cable core

[SOURCE: IEV 461-11-08]

3.19
product family
group of products to be considered to have the same design criteria, the same insulation material characteristics, the same installation technology and the same connector technology

3.20
lug
metallic device to connect a cable conductor to other electrical equipment

[SOURCE: IEV 461-17-01]

4 Components

4.1 Connectors

Conductor connectors used with joints and terminations shall comply with EN 61238-1, where applicable, or with another relevant performance standard. Connectors are considered integral components of accessories and are subject to compliance extensions and limitations detailed in 6.3.

Connectors for circumferential conductors comprising metal wires that are designed to carry neutral or induced current shall meet the electrical requirements of EN 61238-1, where applicable, or those of another relevant performance standard.

4.2 Materials

Component material characterization, either by ‘fingerprinting’ or by type testing, is not a prerequisite for compliance with this performance standard.

If material characterization by type testing is required for components included in the test sample kits, EN 60455-3-8 should be used for resins, and the relevant parts of EN 60684 and EN 62677 for respectively heat-shrink tubing or moulded components if applicable. For “fingerprinting” the appropriate part of HD 631 should be used.

5 Electrical characteristics

5.1 Rated voltage

The rated voltage of the joints, stop ends and outdoor terminations shall be

$$U_0 / U(U_m) = 0,6 / 1,0 \ (1,2) \text{kV}$$

Where

U_0 is the rated power frequency voltage between phase conductor and earth or metallic screen for which the cable accessory is designed;

U is the rated power frequency voltage between phase conductors for which the cable accessory is designed;

U_m is the maximum value of the highest system voltage between phase conductors for which the cable accessory may be used.

5.2 Current rating

The continuous current rating of a joint or termination shall be in accordance with the appropriate cable(s) specified in HD 603 or other relevant cable standard.

6 Range of compliance

6.1 General

Compliance will be gained for a product family of the same design and materials by successfully completing the appropriate test sequence in Tables 3, 4 or 5 on the smallest and the largest accessory in the family. In the case of joints and outdoor terminations, the smallest and largest accessory shall each be tested with the smallest and largest specified cable conductor cross-sections (total 4 samples). Stop-ends shall be tested with the smallest and largest conductor cross-sections (2 samples).

The range of compliance will include these accessories and the intermediate sizes within the family. The number of test samples is shown in Tables 6 to 9. Successful testing with only one cable conductor cross-section shall give compliance for that cross-section only.

6.2 Cables

6.2.1 Compliance is restricted to the use of the accessories on the same cable type (construction and materials) as used in the tests, subject to the permitted extensions given in 6.2.2 to 6.2.5.

6.2.2 Compliance shall extend to the use of the accessories with cables having different conductor material or construction provided that the connectors used in the tests are compliant with 4.1.

6.2.3 Compliance gained for accessories tested on cable with shaped conductors shall extend to the use of the same accessories on cables with circular conductors, subject to the restrictions of 4.1 and 6.3. The converse shall not apply.

6.2.4 Compliance shall extend to use of the accessories with cables having conductor insulation different from that of the test cables in accordance with Table 1.

Table 1 – Summary of compliance with different cable insulations

Cable insulation	Range of compliance
XLPE	XLPE, EPR, PVC
EPR	EPR, PVC
PVC	PVC
Paper	Paper

IPC type connectors shall have been tested on all of the conductor insulation types for which range extension is required.

6.2.5 Compliance gained for accessories tested on cable without longitudinal water-blocking shall extend to their use on water-blocked cable that is otherwise of the same design and materials. The converse shall not apply.

6.2.6 Compliance gained for accessories with a connector tested on cable with longitudinal water-blocked conductors shall extend to their use on cable with non-water-blocked conductor. The converse shall not apply.

6.2.7 Compliance gained for an accessory shall be extended to the use of the same accessory on cables of the same design and materials but with fewer cores.

6.3 Connectors for joints

Compliance gained for joints shall be restricted to the use of the same conductor connectors as those used in the tests, together with other connectors meeting the requirement of 4.1 and falling within the extension limitations detailed in Table 2. The extensions permitted in Table 2 are based on geometrical considerations only and do not imply any similarity or difference in connector performance.

Table 2 – Compliance extension for conductor connectors in joints (based on geometrical considerations)

Connector type used in tests	Compliance extension to connectors of the same type	Compliance extension to connectors of other types
Cylindrical shape straight connector (compression or mechanical)	Connectors with equal or smaller length and envelope diameter [a]	No extension
Non-cylindrical shape straight connector (compression or mechanical)		Cylindrical shape straight connectors with equal or smaller length and envelope diameter
Branch connector		No extension
Multi-polar straight connector		No extension
Multi-polar branch connector		No extension

[a] 'envelope diameter' is the circle diameter, with its plane perpendicular to the main cable conductor, that includes all metallic parts of the connector, including any projecting bolts.

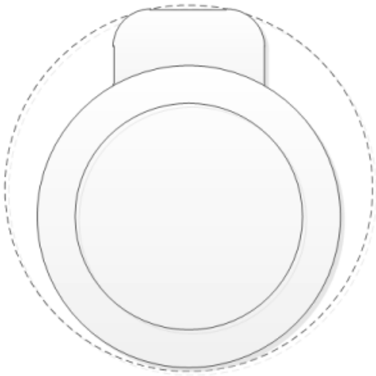


Figure 1 – Example of envelope diameter

6.4 Water immersion depth

The standard water immersion depth for tests on joints and stop-ends is 1 m (gauge pressure 10 kPa (0,1 bar)). For special applications and buried environments subject to a high water table or prone to flooding, this head of water may be considered insufficient to confirm the satisfactory performance of seals preventing the entry of water. In such cases, the test sequence of Tables 3 and 4 may be performed with an increased water head of 10 m (gauge pressure 100 kPa (1,0 bar)). Testing at a single water head will achieve compliance for that water head only. Testing at both 1 m and 10 m water heads will achieve compliance for those water heads and all intermediate values.

6.5 Transition joints

Compliance gained for transition joints shall extend to joints of the same design with an alternative type of solid dielectric cable provided that

– the paper insulated cable is of the same design, construction and materials as that used in the tests, and

– prior compliance has been gained for the use of the alternative solid dielectric cable in straight or branch joints as appropriate.

7 Type tests

7.1 General

Written reports on type tests proving compliance with this European Standard shall be made available by the supplier. The principal details of the test arrangements shall be given in the test report, including details of cable construction (refer to Annex B), accessory test samples (refer to Annex C) and conductor connectors (refer to Annex D). Information in the report should be supported by photographs where relevant.

The test reports shall be signed by a representative of the organization carrying out the tests. This may be the manufacturer, supplier or a recognized certification body.

Should a cable fail beyond any part of an accessory, the test shall be declared void without discrediting the accessory. Tests may be repeated using a new accessory (reverting to the beginning of the test sequence) or alternatively by repair of the cable (continuing testing from the point of suspension).

7.2 Test samples

The number of samples required for each test sequence shall be in accordance with 6.1 and Tables 6 to 9.

Cables used for testing shall comply with HD 603 or other relevant cable standards.

Accessories shall be assembled in the manner specified in the supplier's installation instructions, using the components supplied in the kit. A joint designed for crossed cores shall be so assembled. All assembly instructions shall be included with the test report.

Neither the cable nor the accessories shall be subjected to any form of conditioning not specified in the installation instructions.

Relevant details regarding the test installation shall be recorded in the test report for future reference and to ensure repeatability of the test regime.

7.3 Sequence of tests

The test sequence shall be in the order given in Table 3 to Table 5, as appropriate for the accessory being tested.

Table 3 – Test sequence for joints for solid extruded dielectric insulated cables and for transition joints between solid extruded dielectric insulated cables and impregnated paper insulated cables

Test	Subclause	Samples Type of joints [a]				Requirements
		I	II	III		
		A1/B1	A1/B1	A1/B1	A2/B2	
Impulse voltage withstand at ambient temperature	8.2	-	-	x	-	No failure
AC voltage withstand (in air)	8.3	x	x	x	-	No failure
Insulation resistance (in air)	8.4	x	x	x	-	Insulation resistance ≥ 50 MΩ
Impact at ambient temperature	8.5	-	x	-	-	-
Insulation resistance (immersed)	8.4	-	x	-	-	Insulation resistance ≥ 50 MΩ
Heating cycle in air	8.6	x	x	x	-	63 cycles
Heating cycle in water [b]	8.6	-	x	-	-	9 cycles
Insulation resistance [b] (immersed)	8.4	-	x	-	-	Insulation resistance ≥ 50 MΩ
Heating cycle in water	8.6	x	x	x	-	63 cycles
AC voltage withstand (immersed)	8.3	x	x	x	-	No failure
Insulation resistance (immersed)	8.4	x	x	x	-	Insulation resistance ≥ 50 MΩ
Examination	8.8	x	x	x	-	To be recorded
Screen short-circuit [c]	8.9	-	-	-	x	The fuse shall operate before an open circuit develops between the test pin and the screen.

[a] For the definitions of Types I, II and III, see Clause 3. For the explanation of A1/B1 and A2/B2, see Tables 6 and 7.

[b] These tests are applicable only to joints made on non-water-blocked cables with overall metallic screen or armour.

[c] This test is applicable only to joints incorporating an overall metallic screen and is subject to agreement.

Table 4 – Test sequence for stop ends on solid extruded dielectric insulated cables

Test	Subclause	Samples Type of stop end [a]			Requirements
		I	II	III	
		C1	C1	C1	
Impulse voltage withstand at ambient temperature	8.2	-	-	x	No failure
AC voltage withstand (in air)	8.3	x	x	x	No failure
Insulation resistance (in air)	8.4	x	x	x	Insulation resistance ≥ 50 MΩ
Impact at ambient temperature	8.5	-	x	-	
AC voltage (immersed)	8.3	-	x	-	No failure
Insulation resistance (immersed)	8.4	-	x	-	Insulation resistance ≥ 50 MΩ
Immersion (21 days)	8.7	x	x	x	
AC voltage withstand (immersed)	8.3	x	x	x	No failure
Insulation resistance (immersed)	8.4	x	x	x	Insulation resistance ≥ 50 MΩ
Examination	8.8	x	x	x	To be recorded

[a] For the definitions of Types I, II and III, see Clause 3. For the explanation of C1, see Table 8.

Table 5 – Test sequence for outdoor terminations on solid extruded dielectric insulated cables

Test	Subclause	Samples Type of termination [a]		Requirements
		I	II	
		D1	D1	
Impulse voltage withstand at ambient temperature	8.2	-	x	No failure nor flashover
AC voltage withstand (in air)	8.3	x	x	No failure
Insulation resistance (in air)	8.4	x	x	Insulation resistance ≥ 50 MΩ
Heating cycle in air	8.6	x	x	63 cycles
Heating cycle in water (Crutch immersed)	8.6	x	x	63 cycles
AC voltage withstand (Crutch immersed)	8.3	x	x	No failure
Insulation resistance (crutch immersed)	8.4	x	x	Insulation resistance ≥ 50 MΩ
Examination	8.8	x	x	To be recorded

[a] For the definitions of Types I and II, see Clause 3. For the explanation of D1, see Table 9.

Table 6 – Number of test samples and conductor cross-section: straight joints

Sequence	Tests	Symbol	Number of samples and conductor cross-section
A1	**General test sequence**		**4 samples [a]:** **Smallest joint in the family:** **One sample with smallest cable conductor cross-section One sample with largest cable conductor cross-section** **Largest joint in the family:** **One sample with smallest cable conductor cross-section One sample with largest cable conductor cross-section**
A2	**Screen short-circuit**		**2 samples with cable conductor cross-section ≥ 150 mm^2**
[a] 2 samples if there is only one joint in the product family.			

Table 7 – Number of test samples and conductor cross-section: branch joints

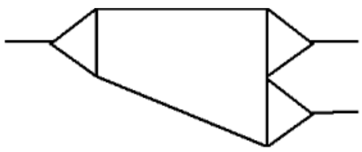
Sequence	Tests	Symbol	Number of samples and conductor cross-section
B1	**General test sequence**		**4 samples [a]:** **Smallest joint in the family:** **One sample with smallest main cable conductor cross-section One sample with largest main cable conductor cross-section** **Largest joint in the family:** **One sample with smallest main cable conductor cross-section One sample with largest main cable conductor cross-section** **All samples to have smallest branch cable conductor cross-section**
B2	**Screen short-circuit**		**Two samples with conductor cross-section ≥ 150 mm^2**
[a] 2 samples if there is only one joint in the product family.			

Table 8 – Number of test samples and conductor cross-section: stop ends

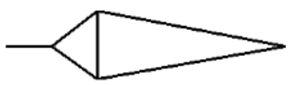
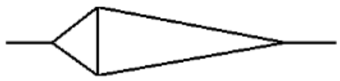
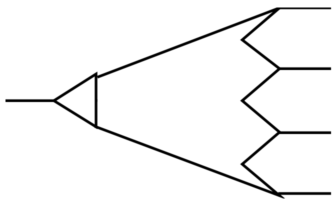
Sequence	Tests	Symbol	Number of samples and conductor cross-section
C1	**General test sequence**		**2 samples:** **- one sample with smallest cable conductor cross-section** **- one sample with largest cable conductor cross-section**

Table 9 – Number of test samples and conductor cross-section: outdoor terminations

Sequence	Tests	Symbol	Number of samples and conductor cross-section a
D1	**General test sequence**		**4 samples [a]** **Smallest termination in the family:** **One sample with smallest cable conductor cross-section** **One sample with largest cable conductor cross-section** **Largest termination in the family:** **One sample with smallest cable conductor cross-section** **One sample with largest cable conductor cross-section**

[a] 2 samples if there is only one termination in the product family.

or

Sequence	Tests	Symbol	Number of samples and conductor cross-section a
D1	**General test sequence**		**4 samples [a]** **Smallest termination in the family:** **One sample with smallest cable conductor cross-section** **One sample with largest conductor cross-section** **Largest termination in the family:** **One sample with smallest cable conductor cross-section** **One sample with largest cable conductor cross-section**

[a] 2 samples if there is only one termination in the product family.

8 Test methods

8.1 General

8.1.1 Test conditions

Tests shall be made at an ambient temperature within the range (20 ± 15) °C, unless otherwise stated in the details of a particular test.

Tap water shall be used for all tests in water.

The frequency and waveform of power frequency test voltages shall be in accordance with EN 61180-1:1994, Clause 5.

The test shall be started not less than 24 h after the installation of the accessories on the cable test loops.

Cable screen and armour, if any, shall be bonded and earthed at one end only to avoid circulating currents.

8.1.2 Temperature calibration of cable

8.1.2.1 Application

The calibration procedure applies in cases where no control cable is included in the current cycling circuit.

Calibration shall apply to all cables that are to be heated in the test sequences.

8.1.2.2 Test procedure

Temperature calibration of cable shall be carried out before the test sequence by application of methods 1 or 2 given in Annex A, or by any equivalent method.

8.2 Impulse voltage withstand test at ambient temperature

8.2.1 Test installation

The accessory shall be installed in a test loop in accordance with the supplier's installation instructions.

8.2.2 Test procedure

The test shall be conducted at ambient temperature as defined in EN 61180-1.

Impulses shall be applied to each phase in turn with the other phases, neutral and screen earthed.

A series of 10 positive and 10 negative impulses shall be applied at the values below:

– 8 kV for accessories installed on a main cable with conductor cross section ≤ 50 mm^2;

– 20 kV for accessories installed on a main cable with conductor cross section > 50 mm^2.

NOTE In the case of a branch joint, the conductor cross-section of the branch cable is not relevant.

8.3 AC voltage withstand test

8.3.1 Test installation

Joints and stop ends: The test shall be carried out on the samples immersed in the water bath or pressure vessel, or in air as specified in Tables 3 and 4. For immersion depth refer to 6.4 and Figure 3.

Outdoor terminations: The test shall be carried out in air or with the crutch immersed in water as specified in Table 5. For immersion depth refer to 8.6.2 and Figure 4.

8.3.2 Test procedure

An AC voltage of 4 kV shall be applied for 1 minute between each phase conductor in turn and all other phase conductors, metallic parts and water electrically bonded together.

If the neutral conductor of the cable is insulated it shall be treated as another phase conductor for the purpose of this test.

8.4 Insulation resistance test

8.4.1 Test installation

The test shall be carried out on the accessories subjected to the main test sequence.

8.4.2 Test procedure

Insulation resistance shall be measured using an instrument with an operating voltage of 500 V or 1 000 V DC.

The DC test voltage shall be applied for sufficient time to reach a steady measurement, but for not less than 1 min and not more than 5 min. Insulation resistance measurements shall be made at ambient temperature.

Prior to immersion in water: The insulation resistance shall be measured between each phase conductor in turn and the other phase conductors and all other metallic parts electrically bonded together.

For the purpose of this part of the test the neutral shall be treated as another phase conductor.

After immersion in water: The insulation resistance shall be measured between each phase conductor in turn and all other phase conductors, metallic parts and water electrically bonded together.

For the purpose of this part of the test the neutral shall be treated as another phase conductor provided the sheath damage in the load cycling test has not brought it in contact with the water. If the neutral conductor is in contact with the water it shall be bonded with the other metallic parts.

8.5 Impact test at ambient temperature

8.5.1 Test installation

The test shall be performed on joints or stop ends subjected to the main test sequence (Type II joints and stop-ends). The number of impacts shall be as specified below.

8.5.2 Test procedure

The accessory shall be placed in a box on a hard surface, e.g. a concrete slab or floor, and the box shall be filled with sand to the horizontal centre of the accessory as shown in Figure 1.

The impacting tool shall be a wedge-shaped steel block of 4 kg mass having a 90° angle with a 2 mm radius impacting edge of minimum width 50 mm. The block shall be dropped on to the accessory from a height of $1\,000^{+20}_{0}$ mm, so that the impacting edge is horizontal, at right angles to the axis of the accessory, and centred on the point of impact.

The impact shall be made at the mid-point of the moisture seal at each cable entry, and on the body of the joint near to the mid-point of the connector(s).

The accessory shall be immersed in water with a head of $1\,000^{+20}_{0}$ mm above the cable entry for a minimum of 3 h before carrying out the AC voltage and insulation resistance tests. The time of immersion may be extended over one night for convenience.

8.6 Heating cycle test

8.6.1 Test installation

The test shall be carried out on the accessories subjected to the main test sequence. The conductor temperature should be determined according to one of the three methods given in Annex A or an appropriate alternative method.

For methods 1 and 2 the arrangements are shown in Figures 2, 3 and 4. The conductor temperature shall be monitored by measuring the temperature of the sheath of the external cable by a thermocouple attached to the sheath 1 000 mm (minimum) outside the accessory for tests in air or 500 mm (minimum) above the water level for tests in water and 500 mm (minimum) from the external crutch, as shown in Figures 2 and 3. The conductor temperature shall be established from the relationship derived in the test in 8.1.2. If the ambient temperature varies by more than 10 K from the temperature at which the calibration test in 8.1.2 was carried out, a further calibration shall be made.

The electrical connections for various accessories are shown in Figure 5 to Figure 8.

8.6.2 Test procedure

The total cycle shall be completed within 8 h. A typical heating and cooling cycle is shown in Figure 9.

Joints shall be subject to 63 cycles in air followed by 63 cycles immersed in water. Branch cables with conductor cross section ≤ 50 mm^2 shall not be heated. Joints of Type II installed on cables with metallic screen or armour shall be subject to an additional 9 cycles immersed in water but without sheath damage. The purpose of the 9 cycle test is to demonstrate the effectiveness of the seal of the joint to the oversheath of the cables.

Outdoor terminations shall be subjected to 63 cycles in air followed by 63 cycles with the crutch only immersed. For convenience, the in-air cycles may be carried out in the empty water bath, but provision shall be made for air circulation by natural convection.

Care should be exercised if cable incorporates magnetic armouring.

In air:

The temperature of the main cable phase conductors (and branch conductors when larger than 50 mm^2) shall be raised to between 5 K and 10 K above the maximum rated temperature by passing current through the cables, as shown in Figures 5 to 8. A steady conductor temperature shall be maintained for not less than 2 h. After the 2 h minimum steady temperature period the current shall be switched off and the cable allowed to cool naturally to within 10 K of ambient within a period not less than 3 h. Forced cooling shall not be used.

In water:

Joints: for the 63 cycle test (following the 9 cycle test for Type II joints) the core(s) of one polymeric insulated cable shall be exposed near its entry to the joint by removing an annulus of the oversheath together with any bedding or filling material of at least 50 mm length at a position between 50 mm and 150 mm from the end of the joint. The exposure of the core(s) shall be made on the side with the shorter length between the sheath cut back and connectors. The assembly shall be placed in a water bath or pressure vessel with a water head of $h = 1\,000\,^{+20}_{0}$ mm (or as otherwise specified) above the main cable entry (refer to 6.4 and Figure 3).

For the 9 cycle test applied to Type II joints the cable oversheath is left intact.

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

Outdoor terminations: the thermocouple may be placed as shown in Figure 4. The water head over the uppermost crutch seal position shall be h = (300 + 100 / −0) mm.

During the heating cycle the temperature of the water shall be (20 ± 15) °C.

Conductor temperatures shall be recorded during each of the cycles. Any cycle during which the specified minimum conductor temperature is not reached shall be rejected and additional cycles carried out to achieve the required number.

8.7 Immersion test – test installation

The cores of the cable shall be exposed by removing an annulus of the oversheath and any bedding or filling material over a length of at least 50 mm, starting at a point 50 mm from the cable entry.

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

The test sample shall be immersed in a water bath (or pressure vessel) with a head of $1\,000_{0}^{+20}$ mm, or as otherwise specified, above the cable entry of the stop end (see 6.1). The sample shall remain immersed for 21 days and during this time the temperature of the water shall remain in the range (20 ± 15) °C.

After 21 days the sample shall undergo the AC voltage withstand test specified in 8.3 followed by insulation resistance measurement in accordance with 8.4 while still immersed in water.

8.8 Examination

8.8.1 General

The results of examination of tested accessories are for information only. It is required that observations from the examination together with relevant photographs be included in the test report.

It is strongly recommended that the manufacturer or supplier be involved in the examination and its findings.

8.8.2 Procedure

Accessories to be examined are those that have completed the main test sequences.

They should be dismantled as far as is practicable to reveal the principal components. Photographs should be taken at appropriate stages of the examination.

Particular attention should be paid to the condition of primary seals and their effectiveness in preventing the ingress of moisture. It is recommended that, prior to the examination, the manufacturer or supplier of the accessory identifies moisture seals and the parts of the accessory from which moisture shall be excluded to ensure reliable operation in service. The examination procedure should include the identification of any cracks, splits, corrosion, leakage of insulation material, evidence of over-heating or thermo-mechanical effects.

8.9 Metallic screen short-circuit current withstand test

8.9.1 General

The objective of this test is to check that, when the joint is pierced by a metallic hand tool, the circuit protection operates before disintegration of the screen. It is applicable to straight and branch joints only where the conductor cross-section is 150 mm^2 and above, on networks protected by fuses. The size of fuse to be used in the test shall be subject to agreement between the user and the supplier.

8.9.2 Test installation

The general arrangement of the test joint, including resistance and fuse, is shown in Figure 10.

Two joints shall be made which shall be additional to those subjected to the main test sequence.

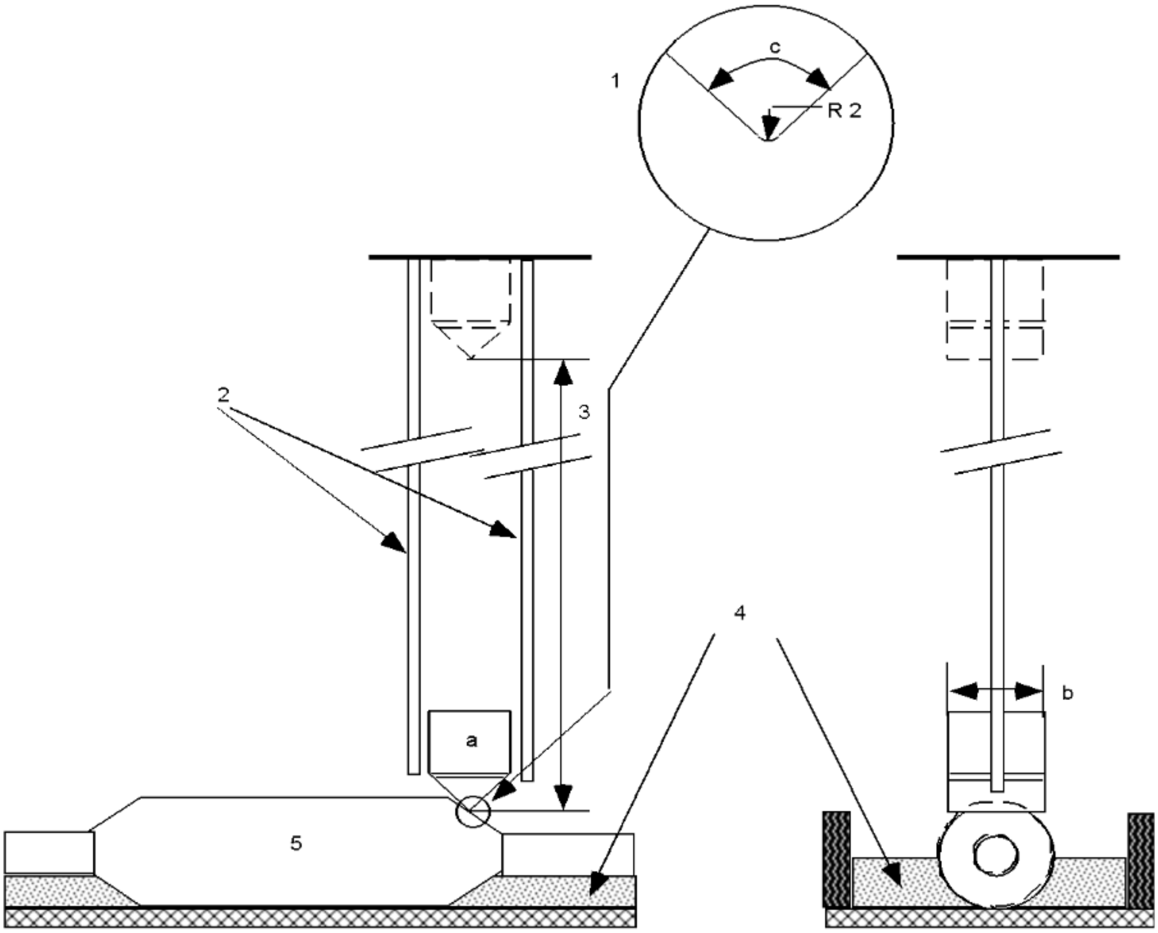
During the making of each joint, a length of insulated copper braid or conductor of a minimum cross-sectional area of 50 mm^2 shall be connected to one phase and brought out of the joint to be connected to a copper test pin of diameter 8 mm.

A hole of maximum diameter 6 mm shall be drilled into the joint and the test pin shall be inserted to make connection with the screen.

8.9.3 Test procedure

The current source shall be set up to deliver a phase to earth short circuit current, I_{sc}, the value to be agreed between the user and the supplier. The open circuit voltage between the test phase and earth shall be 230 V.

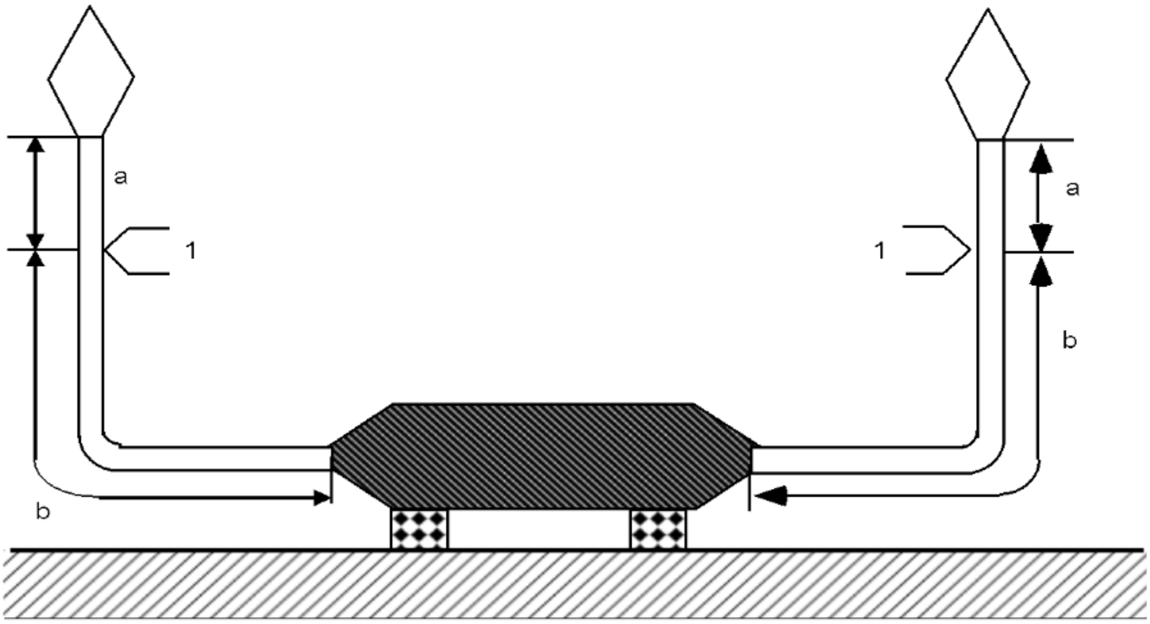
The short-circuit current and the voltage shall remain in phase throughout the test.



Key

1	**detail of impacting edge**	**5**	**joint**
2	**guide rail to ensure correct orientation at point of impact**	**a**	**4 kg impacter**
3	**falling distance: 1 000 mm**	**b**	**50 mm min.**
4	**sand support to joint centre line**	**c**	**90°**

Figure 2 – Typical arrangement for the impact test for joints at ambient temperature



Key

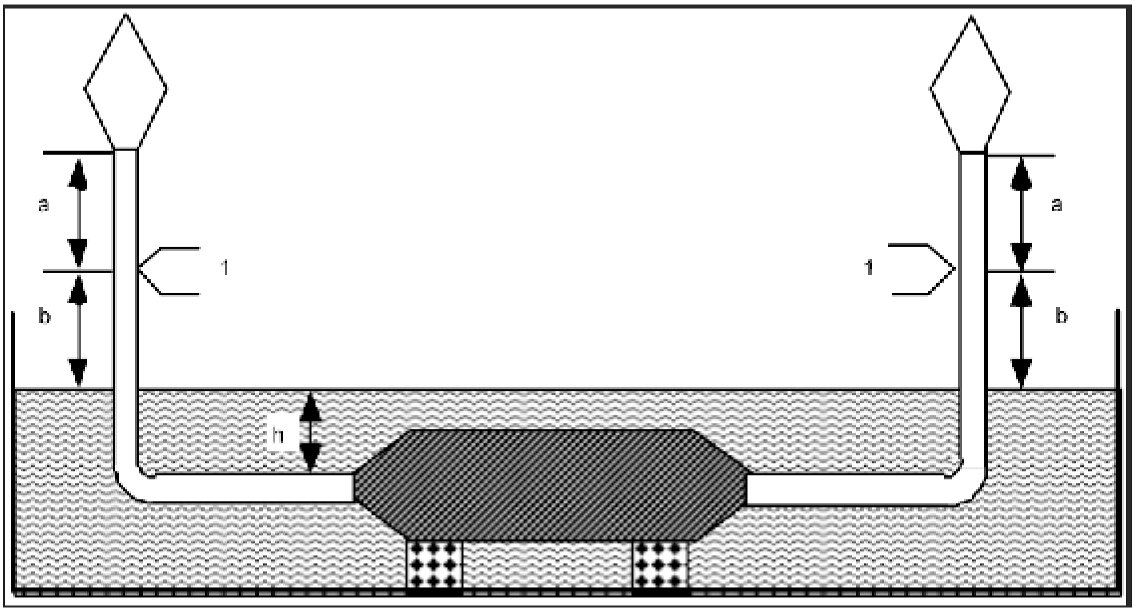
1 thermocouple

a 500 mm min.

b 1 000 mm min.

NOTE For convenience, this part of test may be conducted in the empty water bath.

Figure 3 – Typical arrangement for the heating cycle for joints in air



Key

1 thermocouple

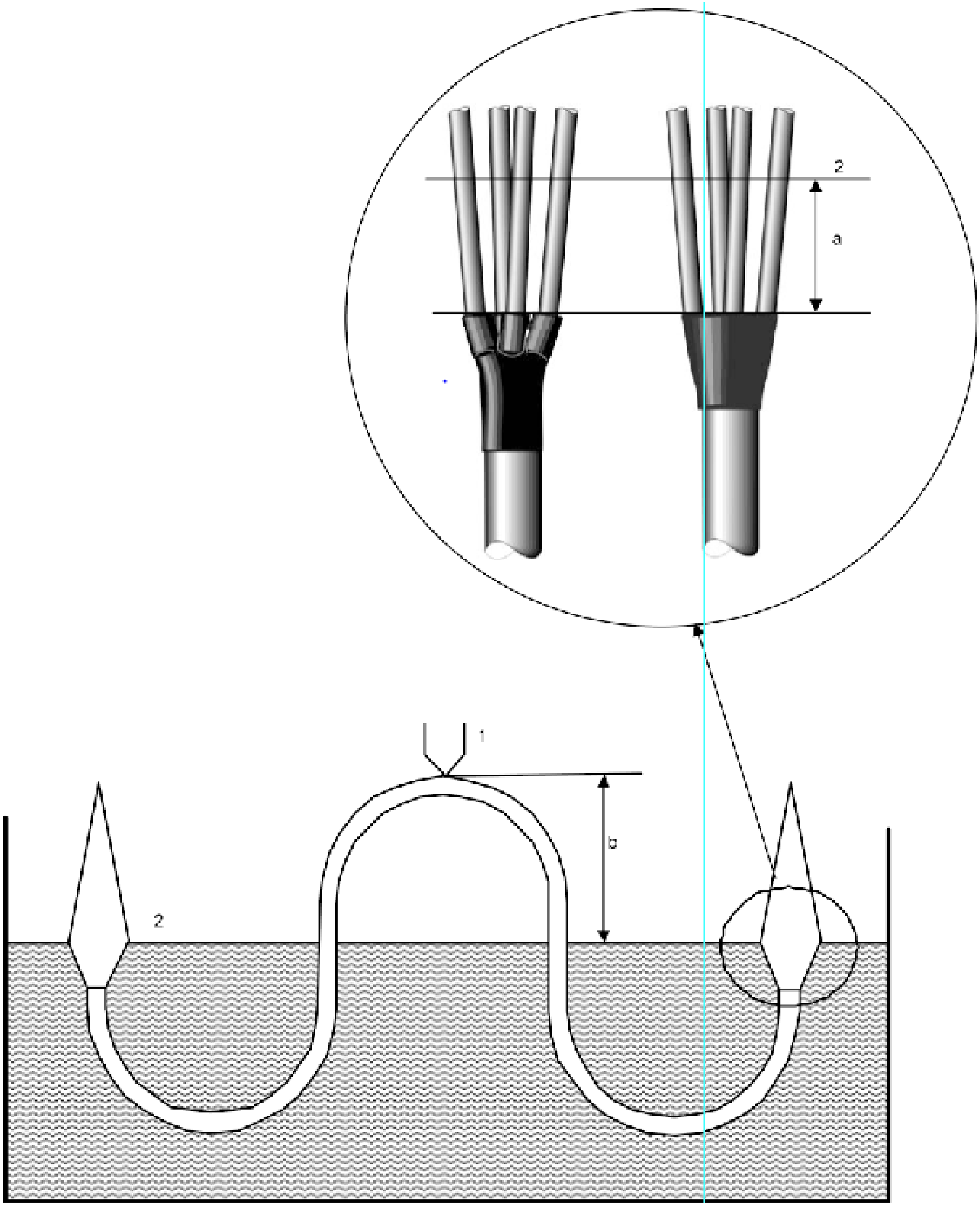
a 500 mm min.

b 500 mm min.

h head of water (refer to 6.4)

NOTE If a pressure vessel is used, it shall incorporate means of registering pressure and water level.

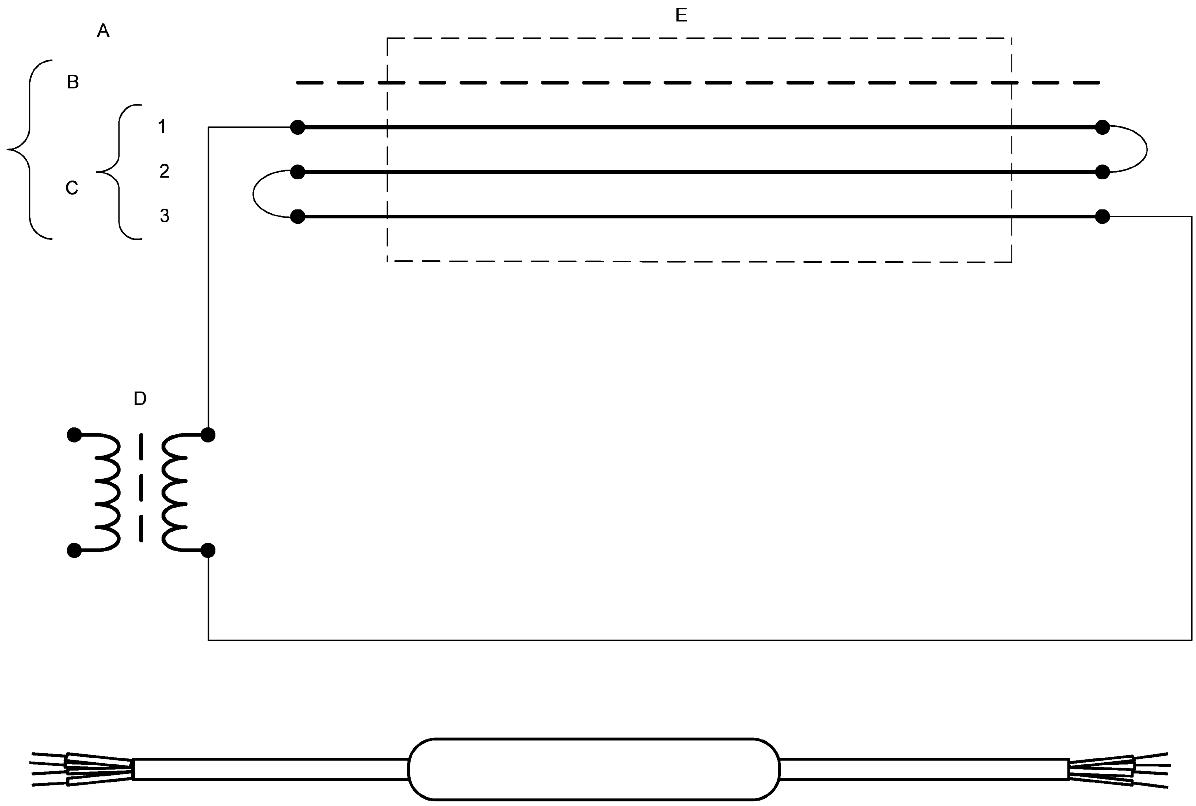
Figure 4 – Typical arrangement for the heating cycle test for joints in water



Key

1	**thermocouple**	**a**	**300 mm min.**
2	**water level**	**b**	**500 mm min.**

Figure 5 – Typical arrangement for the heating cycle test for outdoor terminations in water



Key

A **main cable**

B **neutral**

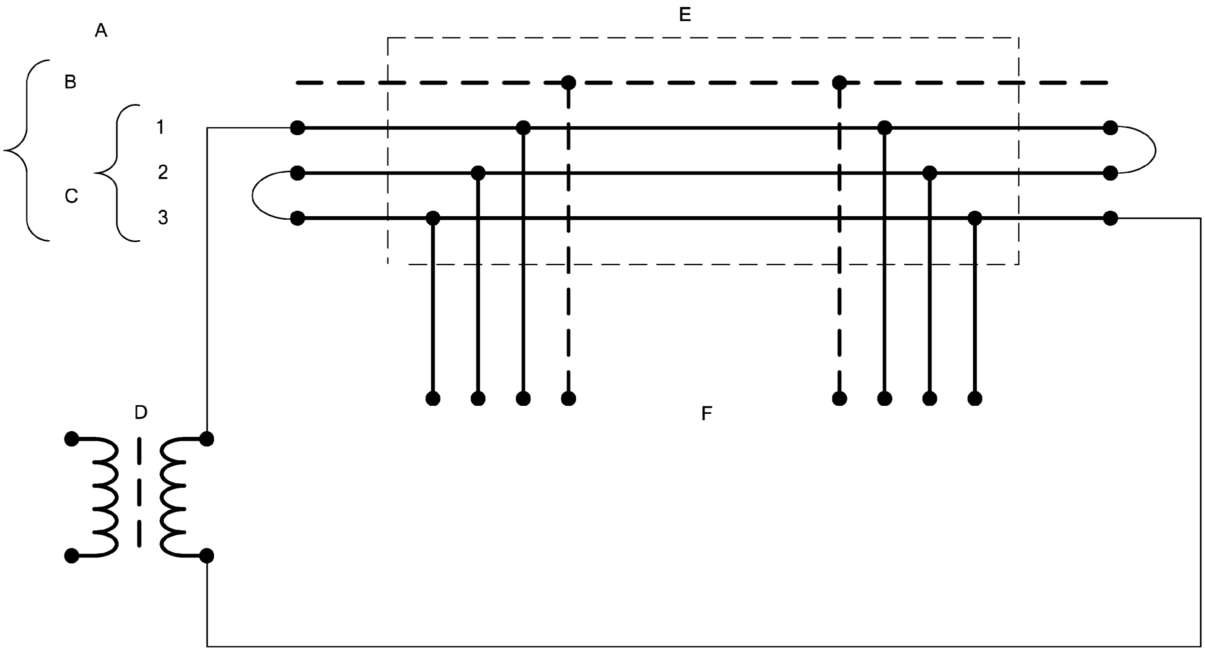
C **phases**

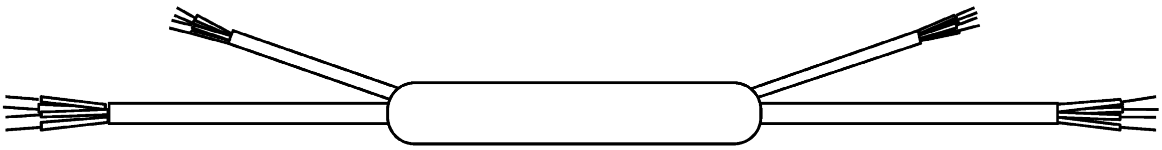
D **current transformer**

E **outline of the straight joint**

NOTE Example only.

Figure 6 – Method of connection of three-phase cables for the heating cycle test on a straight joint





Key

A **main cable**

B **neutral**

C **phases**

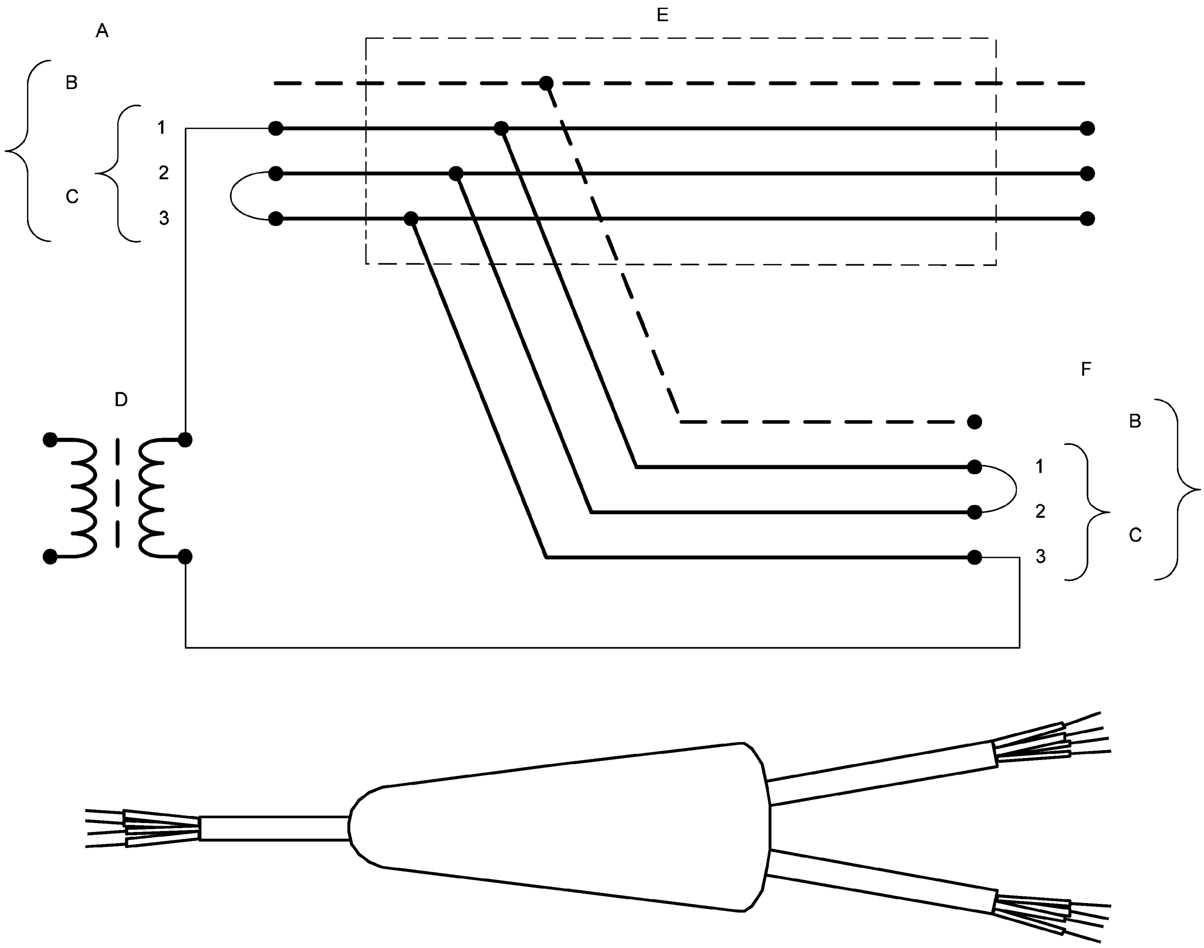
D **current transformer**

E **outline of the branch joint**

F **branch cables unloaded**

NOTE Example only.

Figure 7 – Method of connection of three-phase cables for the heating cycle test on a branch joint where the main cable conductor cross-section is greater than 50 mm^2 and the branch cable conductor cross-section is less than or equal to 50 mm^2



Key

A **main cable**

B **neutral**

C **phases**

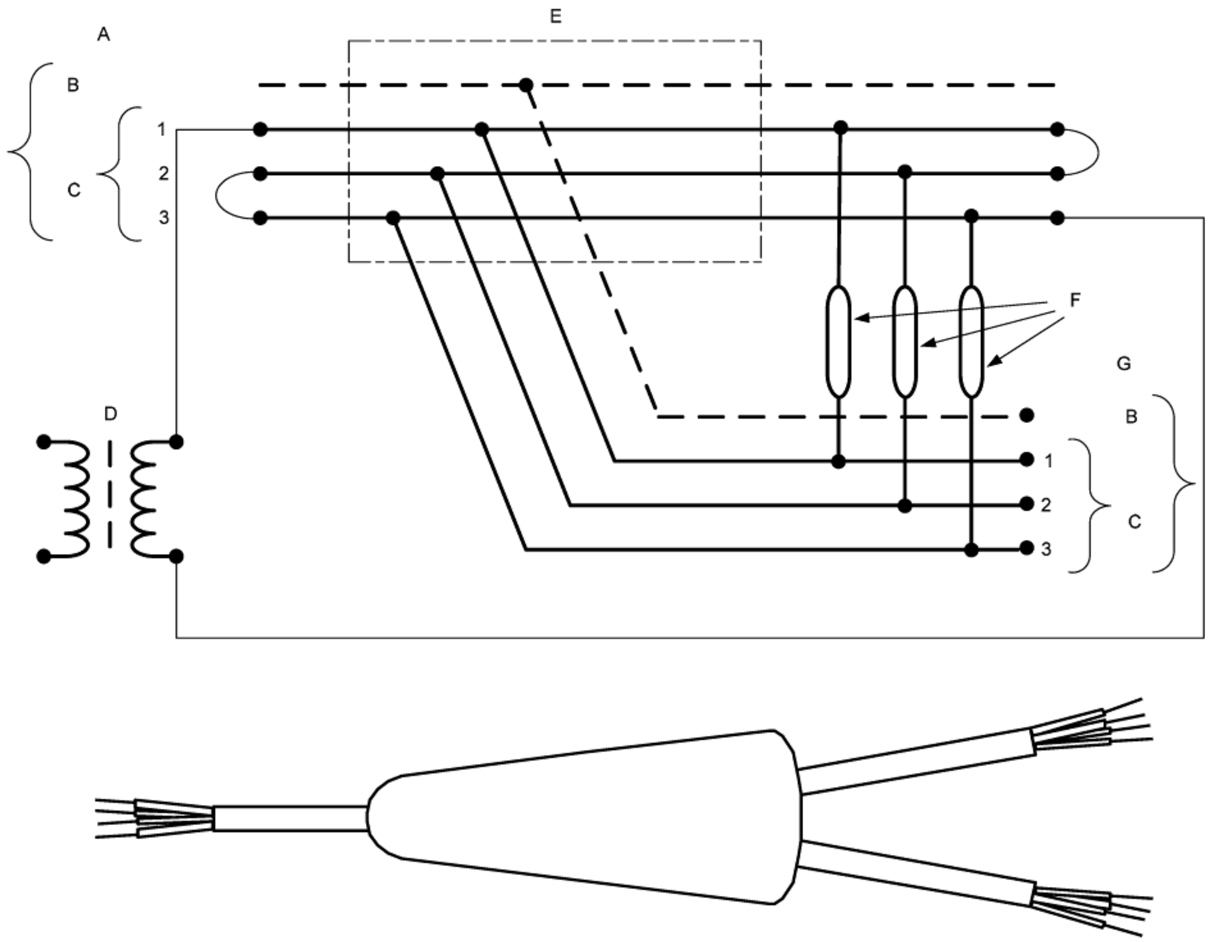
D **current transformer**

E **outline of the branch joint**

F **branch cable**

NOTE Example only.

Figure 8 – Method of connection of three-phase main and branch cables of equal conductor cross-section for the heating cycle test on a branch joint

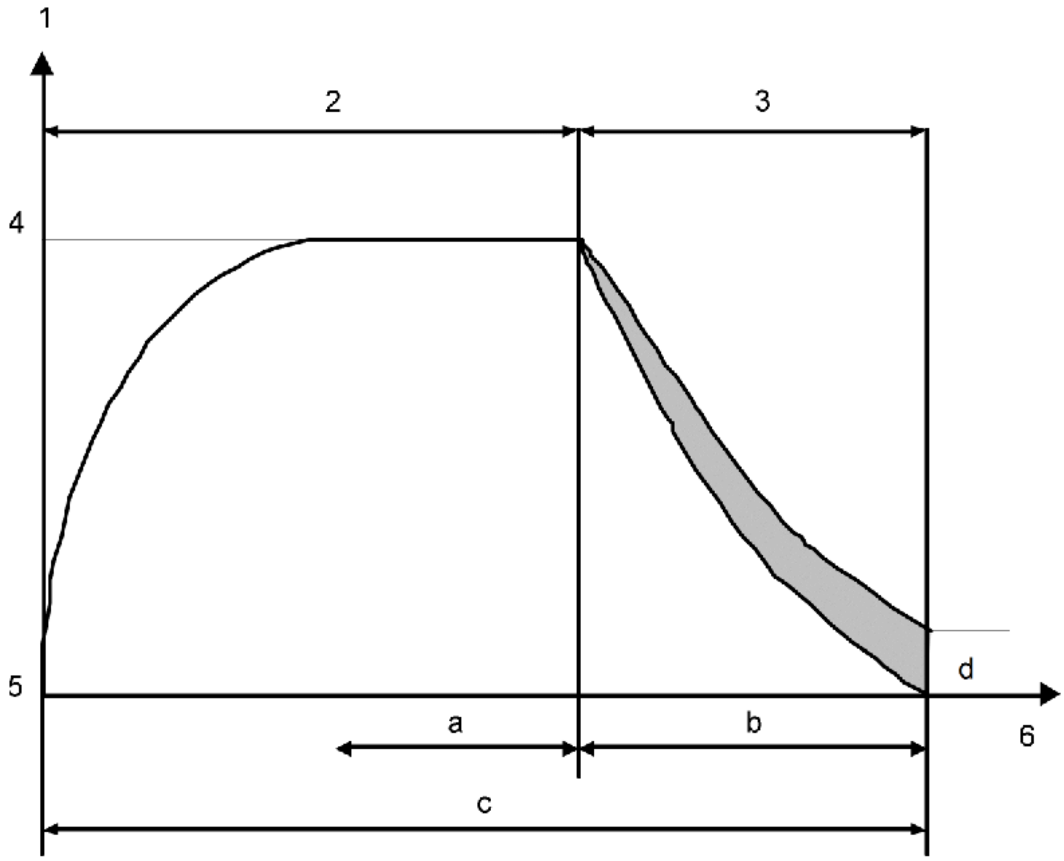


Key

A	**main cable**	**E**	**outline of the branch joint**
B	**neutral**	**F**	**impedances**
C	**phases**	**G**	**branch cable**
D	**current transformer**		

NOTE Example only.

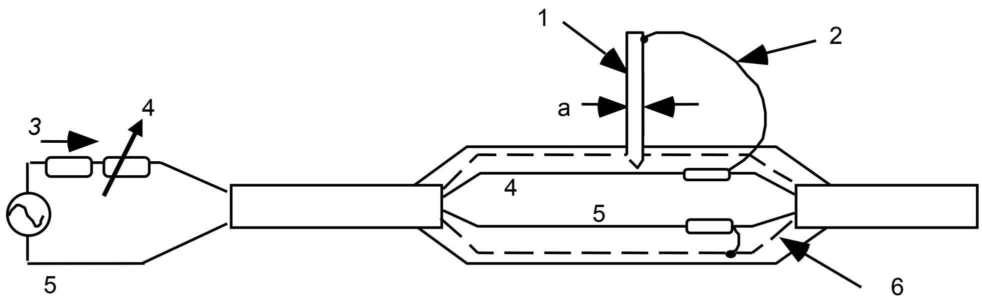
Figure 9 – Method of connection of three-phase main and branch cables of unequal conductor cross-section for the heating cycle test on a branch joint



Key

1	**temperature**	**6**	**time**
2	**heating period**	**a**	**2 h min.**
3	**cooling period**	**b**	**3 h min.**
4	**specified temperature**	**c**	**8 h total**
5	**ambient**	**d**	**10 K**

Figure 10 – Typical heating cycle



Key

1	**copper test pin**	**5**	**neutral**
2	**insulated copper braid or conductor**	**6**	**screen**
3	I_{cc}	**a**	**Ø 8 mm**
4	**phase**		

Figure 11 – Arrangement for the screen short-circuit test

Annex A
(informative)

Determination of cable conductor temperature

A.1 General

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 energised either at power frequency or under impulse conditions.

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

If a control cable is used refer to A.3.4, otherwise 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 2 000 mm, the thermocouples being installed at 500 mm from the cable ends, as shown in Figure A.1.

At each place, two thermocouples should be attached: one on the conductor (d), and one on the external covering (e). The arrangement of thermocouples is shown in the exploded diagram within Figure A.1.

NOTE The thermocouples (e) on the external covering are only necessary if method A.3.3 is to be used.

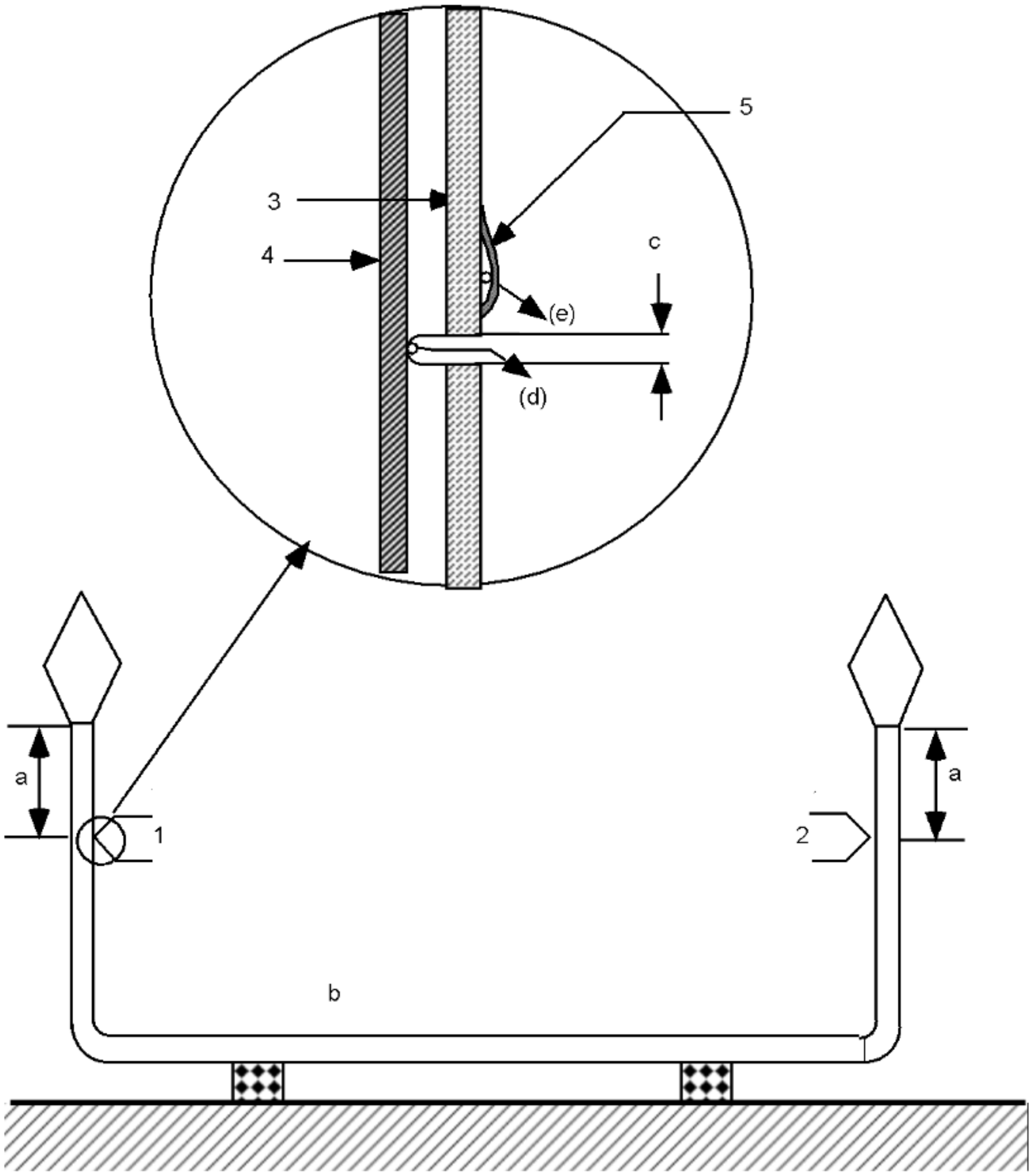
It is recommended that the thermocouples be attached to the conductors by mechanical means since they may move due to vibration of the cable during heating.

If the 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).

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.



Key

1	**thermocouple 1**	**5**	**1 layer copper tape covered with 2 half-lap layers [(d);(e)] adhesive tape**
2	**thermocouple 2**	**a**	**500 mm min.**
3	**sheath**	**b**	**total cable length 2 000 mm min.**
4	**conductor**	**c**	**Ø 1 mm to 2 mm**

Figure A.1 – Arrangement for the cable calibration test

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

– between 5 K and 10 K above the maximum conductor temperature of the cable in normal operation, as given in HD 603, (or other appropriate cable standard) for polymeric cables;

– between 0 K and 5 K above the maximum conductor temperature of the cable in normal operation, as given in IEC 60055-2, for paper insulated cables.

It is considered that stabilization has been reached if the readings of thermocouples a_1 and a_2 do not show any variation larger that 2 K within a 2 h period.

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

– conductor temperature $\theta_c = \dfrac{a_1 + a_2}{2}$;

– sheath temperature $\theta_{sc} = \dfrac{b_1 + b_2}{2}$; b1 and b2 indicating the readings of the thermocouples (e) at positions 1 and 2 of Figure A.1

– ambient temperature θ_{ac};

– heating current I_{cal}.

A.3 Temperature measurement during the test

A.3.1 General

Let:

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

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

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

T' thermal resistance between the conductor and the external covering (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;

$T = T' + nT_4$.

θ_{at} ambient temperature during accessory test;

θ_{st} temperature of external covering during accessory test;

I_{test} current during 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 cable calibration:

$$\theta_c - \theta_{ac} = R_{20}.I_{cal}^2\left[1+\alpha_{20}\left(\theta_c - 20\right)\right]T \qquad \text{(A.1)}$$

– during accessory test:

$$\theta_c - \theta_{at} = R_{20}.I_{test}^2\left[1+\alpha_{20}\left(\theta_c - 20\right)\right]T \qquad \text{(A.2)}$$

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

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

$$I_{test} = I_{cal}\sqrt{\frac{\theta_c - \theta_{at}}{\theta_c - \theta_{ac}}} \qquad \text{(A.3)}$$

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

– during cable calibration:

$$\theta_c - \theta_{sc} = R_{20}.I_{cal}^2\left[1+\alpha_{20}\left(\theta_c - 20\right)\right]T' \qquad \text{(A.4)}$$

– during accessory test:

$$\theta_c - \theta_{st} = R_{20}.I_{test}^2\left[1+\alpha_{20}\left(\theta_c - 20\right)\right]T' \qquad \text{(A.5)}$$

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

$$I_{test} = I_{cal}\sqrt{\frac{\theta_c - \theta_{st}}{\theta_c - \theta_{sc}}} \qquad \text{(A.6)}$$

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

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

$$\theta_c = \frac{\theta_{st} + \left(1-20\alpha_{20}\right)R_{20}.I_{test}^2.T'}{1-\alpha_{20}.R_{20}.I_{test}^2.T'} \qquad \text{(A.7)}$$

It is therefore possible to transpose this formula in the form of a chart (see Figure A.2) giving θ_c from θ_{st} readings, for various heating currents I_{test1}, I_{test2}, …

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

A.3.4 Method 3: Test using a control cable

In this method a cable identical to the cable used for the test is heated with the same current as the test loop. This cable is not energised (no voltage applied) and therefore thermocouples can be fitted to the conductor as recommended in A.2.2 above. This cable is referenced as control cable.

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.

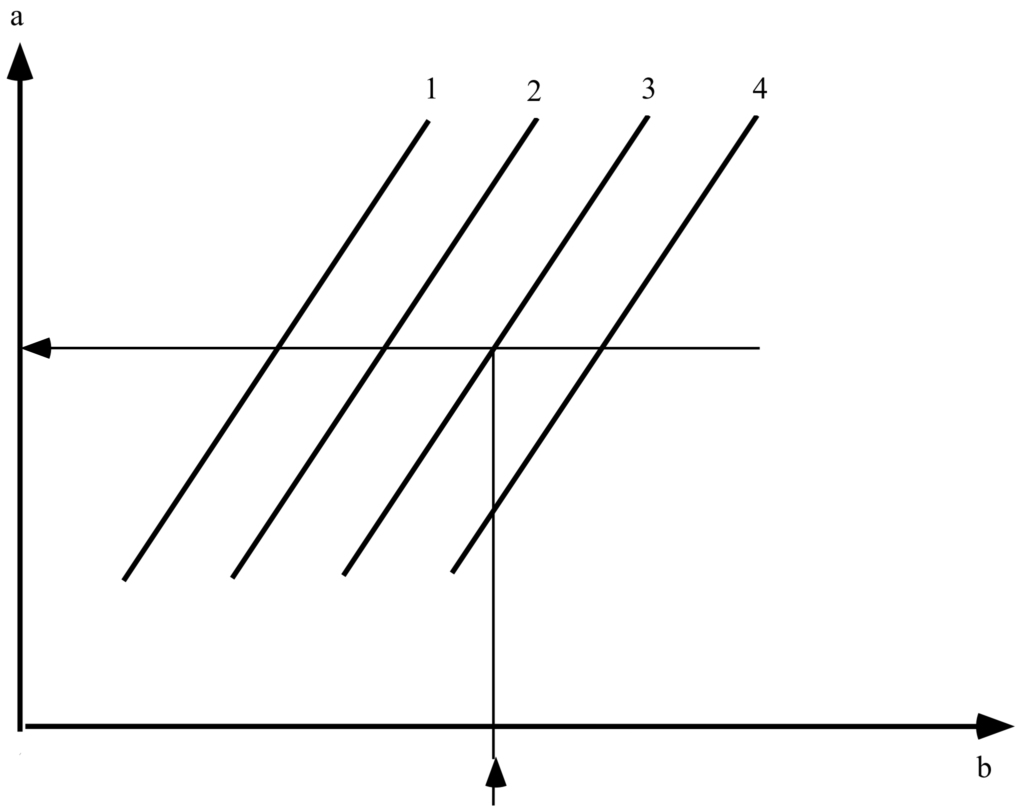
The thermocouples should be mounted on the external surface of the test loop at the positions given in Figure A.1 and similarly on the surface of the control cable. The temperature measured with the thermocouples on the oversheath of the energized test loop and the temperature of the control cable are used to check that the oversheaths are at the same temperature.

Recognizing that not all conductors may be heated during the test, the thermocouple should be installed over the conductor achieving the highest temperature.

The temperature measured with the thermocouple fitted to the conductor of the control loop may be considered as representative of 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 should be adjusted such that the required conductor temperature is kept within the specified limits.



Key

1	I_{Test1}	**4**	I_{Test4}
2	I_{Test2}	**a**	θ_{C}
3	I_{Test3}	**b**	θ_{st}

Figure A.2 – Variation of θ_c with θ_{st} for various heating currents

Annex B
(informative)

Identification of test cable

(Refer to 7.1)

(One sheet for each cable type)

Construction:	☐ 1-core ☐ 2-core ☐ 3-core ☐ 4-core
	☐ 3½ - core Description:…………………………………
	☐ Other:…………………………………………………………
	☐ Overall screen Description:………………………….
Conductors:	☐ Aluminium ☐ Copper
	☐ Stranded ☐ Solid
	☐ Circular ☐ Shaped
	Cross-section: ……… mm^2
Insulation:	☐ XLPE ☐ PVC
	☐ EPR ☐ Paper
Metallic sheath	☐ Lead ☐ Aluminium
Armour:	☐ Wire ☐ Tape
Oversheath:	☐ PVC ☐ PE (state type) ☐ Hessian serving (Jute)
Water blocking:	☐ Within conductor ☐ Under oversheath
Diameters:	• Conductor ……… mm
	• Insulation ……… mm
	• Oversheath ……… mm
Cable marking:	………………………………………………………………

Annex C
(informative)

Identification of accessory test samples

(Refer to 7.1)

(One sheet for each accessory)

Type: ☐ straight joint ☐ branch joint ☐ stop-end ☐ termination

Primary insulation over connectors (e.g. heat-shrink sleeve):	………………………………………
Protection (e.g. cast resin):	……………………………………
Overall dimensions:	……………………………………
Conductor size range for this accessory:	…… mm^2 to …… mm^2
Conductor size range for product family:	…… mm^2 to …… mm^2
Manufacturer/supplier:	……………………………………
Product reference:	……………………………………

Annex D
(informative)

Identification of connector

(Refer to 4.1 and 7.1)

(Use one sheet for each connector type)

Type:	☐ Straight ☐ Branch ☐ Circumferential conductor ☐ Individual ☐ Multi-polar (including ring type) ☐ Blocked ☐ Non-blocked
Technology:	☐ Mechanical Torque if non shear bolt ……………………….. ☐ Compression ☐ Hexagonal ☐ Deep Indent ☐ Other...... Tool and die used: …………………………….. ☐ Insulation piercing
Material	☐ Al ☐ Cu ☐ Bi-metallic ☐ Brass ☐ Tinned ☐ Non-insulated ☐ Insulated Description:
	Manufacturer/Supplier:………………………………… Product reference: …………………………………. Marking: …………………………………………… For dimensions, add data sheet or drawing.

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[1)] Part 1 and Part 2 of EN 62677 are at draft stage.

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