IS 13573-3 (2011): Cable Accessories for Extruded Power Cables, Part 3: for Working Voltages for 3.3kV(UE) upto and Including 33kV(E) - Test Methods [ETD 9: Power Cables]

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भारतीय मानक

एक्सट्रूडेड पावर केबल के लिए केबल सहायकांग — विशिष्टि

भाग 3 3.3 कि.वा. (यू ई) और 33 कि.वा.(ई) तक की रेटित वोल्टेज — परीक्षण अपेक्षाएँ

(पहला पुनरीक्षण)

Indian Standard

CABLE ACCESSORIES FOR EXTRUDED POWER CABLES — SPECIFICATION

PART 3 FOR WORKING VOLTAGES FROM 3.3 kV(UE) UP TO AND INCLUDING 33 kV(E) — TEST METHODS

(First Revision)

ICS 29.060.20;29.120.99

B U R E A U O F I N D I A N S T A N D A R D S
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 2011 **Price Group 7**

Power Cables Sectional Committee, ETD 09

FOREWORD

This Indian Standard (Part 3) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Power Cables Sectional Committee had been approved by the Electrotechnical Division Council.

There are different methods followed for joints and terminations and the basic technique depends on the voltage rating of the power cable for which the accessories needs to be installed.

This standard was originally published as IS 13573 : 1992 'Joints and terminations of polymeric cables for working voltages from 6.6 kV up to and including 33 kV — Performance requirements and type tests'. This revision has been undertaken to bring it in line with international practices. It has been split up into three parts. The other parts in the series are:

Part 1	For working voltages from 1.1 kV up to and including 3.3 kV(E) — Test methods and test requirements
Part 2	For working voltages from 3.3 kV(UE) up to and including 33 kV(E) — Test requirements

The following changes have been incorporated in this revision in addition to the tests as per IEC 60502-4 : 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 4: Test requirements on accessories for cables with rated voltages from 6 kV (U_m = 7.2 kV) up to 30 kV (U_m = 36 kV)':

a) Inclusion of conductor resistance test before and after the sequence of type tests.
b) As a first step towards improvement of quality of components used for the accessories an attempt has been made towards standardization of critical components used for joints and terminations in this standard. The components should meet the requirements as per the guaranteed technical particulars (GTP) of the accessories manufacturer.
c) Marking and labelling of all the components of cable accessories has been included, wherever feasible without changing the characteristics of the components. This helps in identifying the manufacturer's name or logo and identification number as per the catalogues of the jointing kit.
d) The conductor size for preparation of test specimen is from 120 mm^2 or 150 mm^2 or 185 mm^2 or 240 mm^2. In this standard the conductor size of 240 mm^2 is also included. Approval of a range of conductor cross-sectional areas from 95 mm^2 to 400 mm^2 of one type of accessory for both range taking and non-range taking has been covered in this standard.

In the formulation of this standard assistance has been derived from IEC 61442 : 2005 'Test methods for accessories for power cables with rated voltages from 6 kV (U_m = 7.2 kV) up to 30 kV (U_m = 36 kV)' and 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'.

The cable joints/terminations should normally have same electrical and thermal characteristics as the cable for which these are intended. As such this standard is to be used in conjunction with the following:

IS No.	*Title*
1554 (Part 2) : 1988	PVC insulated (heavy duty) electric cables: Part 2 For working voltages from 3.3 kV up to and including 11 kV (*second revision*)
7098 (Part 2) : 1985	Crosslinked polyethylene insulated PVC sheathed cables: Part 2 For working voltages from 3.3 kV up to and including 33 kV (*first revision*)
9968 (Part 2) : 1985	Elastomer insulated cables: Part 2 For working voltages from 3.3 kV up to and including 11 kV

This standard does not cover performance requirements of joints and terminations for paper insulated power cables and transition joints.

(*Continued on third cover*)

Indian Standard

CABLE ACCESSORIES FOR EXTRUDED POWER CABLES — SPECIFICATION

PART 3 FOR WORKING VOLTAGES FROM 3.3 kV(UE) UP TO AND INCLUDING 33 kV(E) — TEST METHODS

(First Revision)

1 SCOPE

This standard (Part 3) specifies the test methods to be used for type testing accessories for screened solid dielectric power cables for voltage grade from 3.3 kV (UE) up to and including 33 kV (E). The accessories includes joints (straight joints and branch joints), terminations, screened and unscreened separable terminations and stop ends.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below:

IS/IEC No.	*Title*
2071 (Part 2) : 1974	Methods of high voltage testing: Part 2 Test procedures (*first revision*)
7098 (Part 3) : 1993	Crosslinked polyethylene insulated thermoplastic sheathed cables: Part 3 For working voltages from 66 kV up to and including 220 kV
8130 : 1984	Conductors for insulated electric cables and flexible cords
8704 : 1995 / IEC 507 : 1991	IEC Artificial pollution test on high voltage insulators to be used on ac systems
10810	Methods of test for cables:
(Part 5) : 1984	Conductor resistance test
(Part 45) : 1984	High voltage test
(Part 46) : 1984	Partial discharge test
13573 (Part 2) : 2011	Cable accessories for extruded power cables — Specification: Part 2 For working voltages from 3.3 kV (UE) up to and including 33 kV (E) — Test requirements
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 as given in IS 13573 (Part 2).

3.2 The numbers of test samples are given in IS 13573 (Part 2).

3.3 The test methods and testing parameters are specified in **4** to **20**. Other test methods shall be as specified in the relevant Indian Standards.

3.4 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.

3.5 During testing, cable screens, and armour if any, shall be bonded and earthed at one end only to prevent circulating currents.

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

3.7 Ambient temperature shall be 20^{+20}_{-5}°C .

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

4 TEST METHODS

4.1 Conductor Resistance

Conductor resistance test shall be carried out on a sample as per relevant part of this standard in accordance with IS 10810 (Part 5). Conductor resistance carried out at the end of heating cycle test shall not vary from the initial value measured by more than 10 percent.

4.2 ac Voltage Test

4.2.1 *Dry Test for All Accessories*

4.2.1.1 *Installation*

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

4.2.1.2 *Method*

Unless otherwise specified, the test shall be made at ambient temperature, and the procedure for voltage application shall be as specified in IS 10810 (Part 45).

4.2.2 *Wet Test for Outdoor Terminations*

4.2.2.1 *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 or according to manufacturer's instructions.

4.2.2.2 *Method*

Unless otherwise specified, the wet test method is as described in IS 10810 (Part 45) shall be carried out at ambient temperature.

4.2.3 *Test in Water for Stop Ends*

4.2.3.1 *Installation*

The stop ends shall be installed in water tank of such dimensions as to have a height of water of $1\,000^{+20}_{-0}$ mm over their top surface, unless otherwise specified. The water shall be at ambient temperature.

4.2.3.2 *Method*

Unless otherwise specified, the procedure for voltage application shall be as specified in IS 10810 (Part 45).

5 DC VOLTAGE TESTS

5.1 Installation

The set(s) of accessories shall be erected with all associated metal work 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 as per relevant clause of IS 10810 (Part 45) at ambient temperature.

6 IMPULSE VOLTAGE TESTS

6.1 Installation

For preparation of the test installation, involving metal enclosures and terminal boxes, reference shall be made to IS 2071(Part 2). 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 IS 10810 (Part 45).

6.3 Test to be Carried Out at Elevated Temperature

Installation and measurement of temperature are given in **8**. During the test, the cable conductor shall be heated and stabilized for at least 2 h at a temperature of 5°C to 10°C above the maximum cable conductor temperature in normal operation.

7 PARTIAL DISCHARGE TEST

7.1 Method

The test shall be conducted in accordance with IS 10810 (Part 46).

7.1.1 *Test at Ambient Temperature*

The partial discharge test shall be carried at ambient temperature.

7.1.2 *Test at Elevated Temperature*

Installation and measurement of temperature are given in **8**. During the test, the cable conductor shall be heated and stabilized for at least 2 h at a temperature of 5°C to 10°C above the maximum cable conductor temperature in normal operation and the partial discharge shall be measured at the test voltage as given in IS 13573 (Part 2).

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 magnetic covering, a three-phase heating current shall be applied.

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

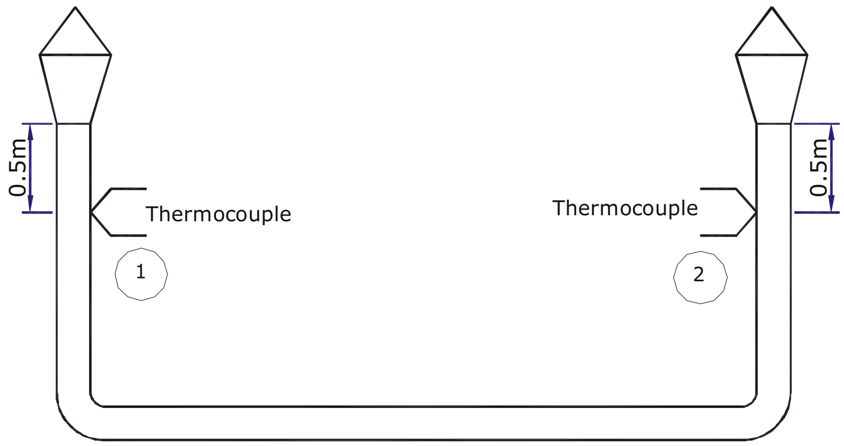


FIG. 1 TERMINATIONS TESTED IN AIR

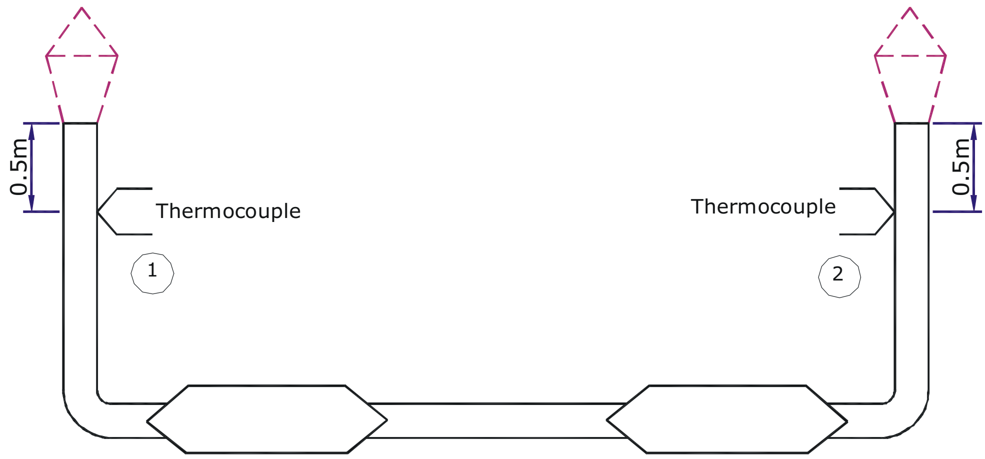
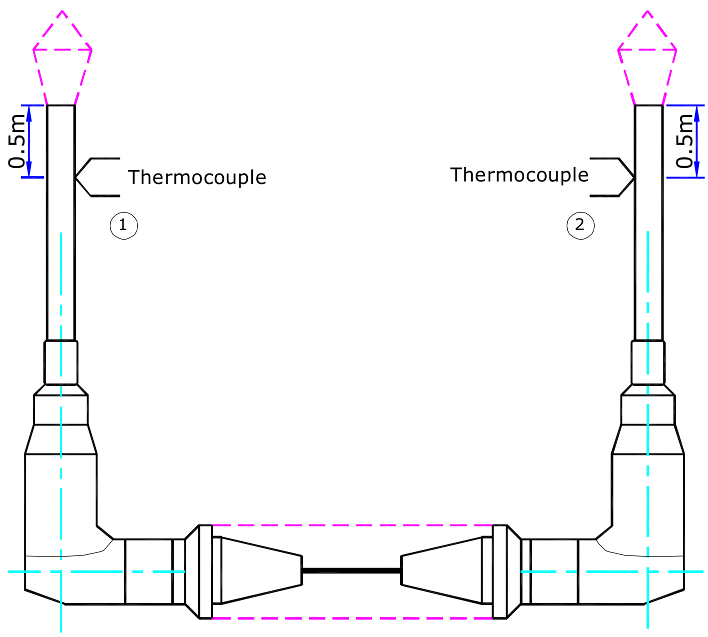
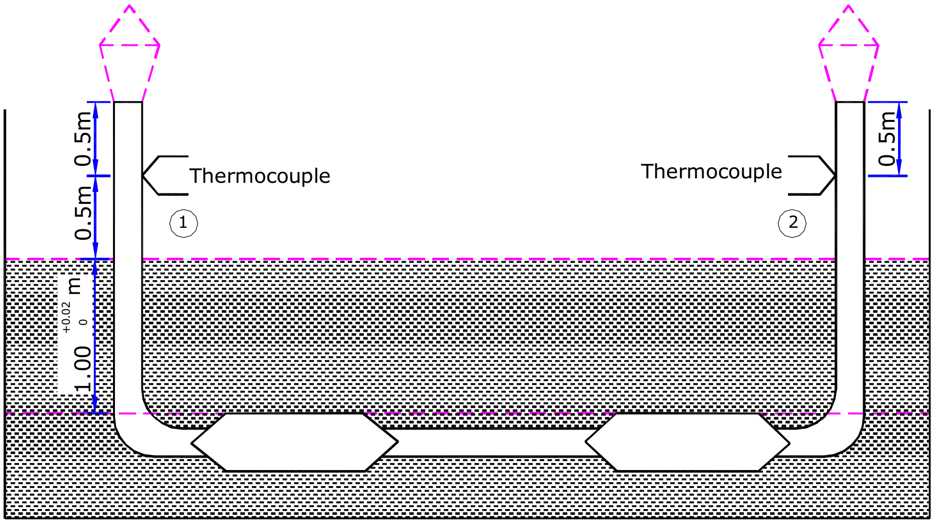


FIG. 2 JOINTS TESTED IN AIR



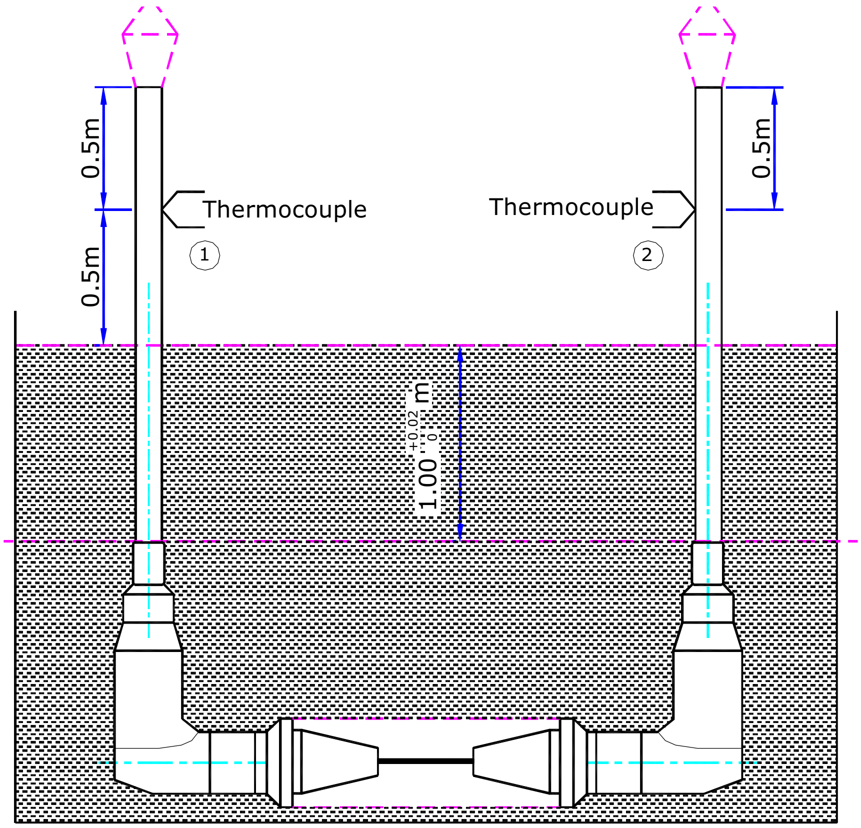
NOTE — The height of the water is as indicated, unless otherwise specified.

FIG. 3 SEPARABLE CONNECTORS TESTED IN AIR



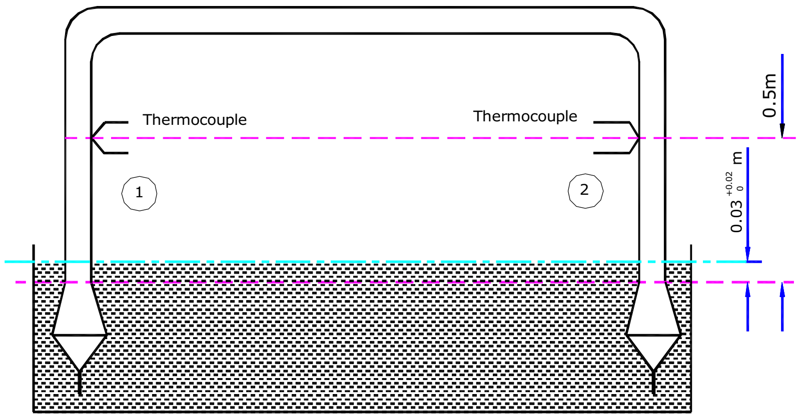
NOTE — The height of the water is as indicated, unless otherwise specified.

FIG. 4 JOINTS TESTED UNDER WATER



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

FIG. 5 SEPARABLE CONNECTORS TESTED UNDER WATER



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

FIG. 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 **8**. Measurement of temperature is also given in **8**. Each heating cycle in air or water shall be of at least 2 h at a steady temperature of 5°C to 10°C above the maximum cable conductor temperature in normal operation for extruded insulation cables.

Followed by at least 3 h of natural cooling to within 10°C of ambient temperature (*see* Fig. 7).

9.2 Test in Air

The test assembly shall be subjected to the required number of heating cycles energized at the voltage given in IS 13573 (Part 2).

9.3 Test in Water

For heat cycling in water, joints or separable connectors shall be installed in a vessel or water tank so as to have a height of water $1\,000^{+20}_{-0}$ mm 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 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 the connectors.

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 IS 13573 (Part 2).

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

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 30^{+20}_{-0} mm 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* Fig. 6).

9.4.2 *Method*

The test loop shall be subjected to 10 cycles under the conditions given in **9.1** without the application of voltage.

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.

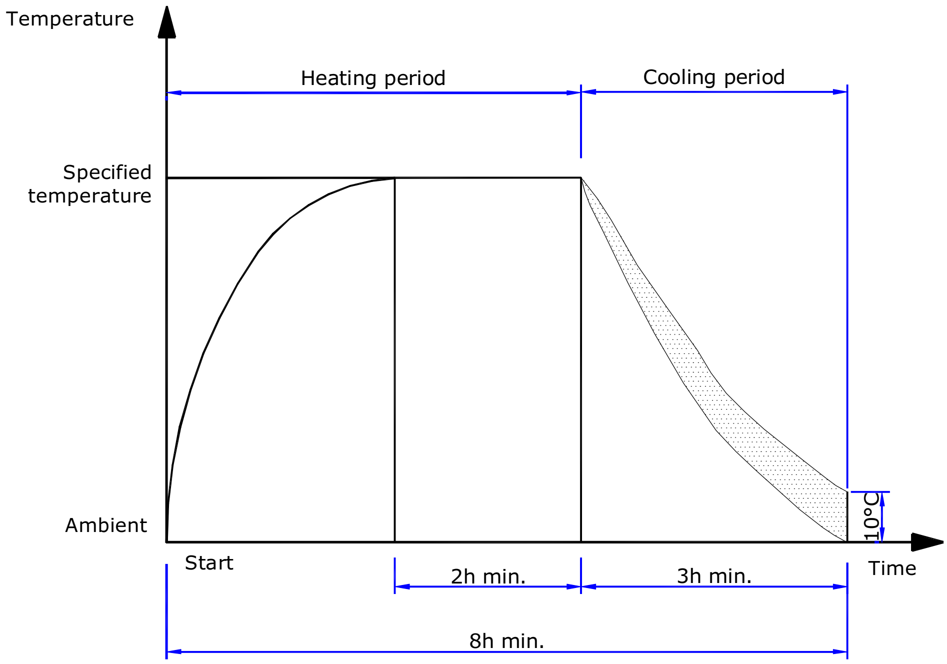


FIG. 7 HEATING CYCLE

10.2 Method

The current (I_{smm}) and duration (t) for the test shall be as agreed to 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 **8**.

The cable conductor shall be heated and stabilized for at least 2 h at a temperature of 5°C to 10°C above the maximum cable conductor in normal operation for extruded insulation 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°C above its temperature prior to the first short-circuit.

11 THERMAL SHORT-CIRCUIT TEST (CONDUCTOR)

11.1 Installation

The test loop shall consist of cables 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 IS 13573 (Part 2).

11.2 Method

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

Two short-circuits shall be applied using either ac or dc to raise the conductor temperature to the maximum permissible short-circuit temperature of the cable (θ_{sc}) within 5s. Between the two short-circuits, the test loop shall be allowed to cool to a temperature less than 10°C above it's temperature prior to the first short-circuit (θ_i).

The maximum permissible short-circuit temperature of the cable conductor is given in Annex B.

The following formulae shall be used:

For aluminum conductors:

$$I^2t = 2.19 \times 10^4 \times S^2 \times \ln\{(\theta_{sc} + 228)/(\theta_i + 228)\}$$

For copper conductors:

$$I^2t = 5.11 \times 10^4 \times S^2 \times \ln\{(\theta_{sc} + 234.5)/(\theta_i + 234.5)\}$$

where

I = r.m.s. value of short-circuit current, in A;

t = duration, in s;

S = conductor cross-sectional area, in mm^2;

θ_{sc} = permissible short-circuit conductor temperature, in°C;

θ_i = conductor temperature at the start of test, in°C; and

ln = $\log_e$.

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 as given in Annex D of IEC 61238-1 : 2003.

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 consists 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 IS 13573 (Part 2).

For terminations, separable connectors and joints, the cable and accessories clamping method and the spacing between the accessories shall be 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 standard, is reached.

The peak current of 2.55 times the thermal short-circuit current shall be established with oscillograph. The duration of the current should be selected in such a way that at least half cycle is achieved during the test. The voltage applied to the test circuit should not be higher than required to achieve the short circuit current.

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 ac voltage source is required. The maximum voltage drop at the high voltage side of the source shall be less than 5 percent 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 C 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 or according to the manufacturer's instruction.

Three unscreened separable connectors or three shrouded terminations (either single or three core accessories) shall be mounted in a test terminal box and subjected to a single or three-phase voltage (either single core connected to high voltage and other two cores connected to earth or all three cores connected to HV source depending on the test source as the case may be).

Three-core terminations shall also be subjected to a single or three-phase voltage source. These tests do not reveal any parameters between adjacent phases during testing.

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 ± 0.1 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 test voltage of the tests are given in IS 13573 (Part 2).

Cleaning of 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 and photographs of the condition of the accessories.

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 dc test voltage shall be in the range of 100 V to 1 000 V and shall be applied for a sufficient time to reach reasonably steady measurement, but in any case not less than 1 min and not more than 5 min.

The joint shall be placed on a hard base, for example a concrete slab or floor, and solidly supported in a box filled with sand up to the horizontal centre line of the accessory (*see* Fig. 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 1 000 mm onto the joint so that the impacting edge is horizontal and at right angles to the axis of the point. 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 $1\,000^{+20}_{-0}$ mm 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.

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.

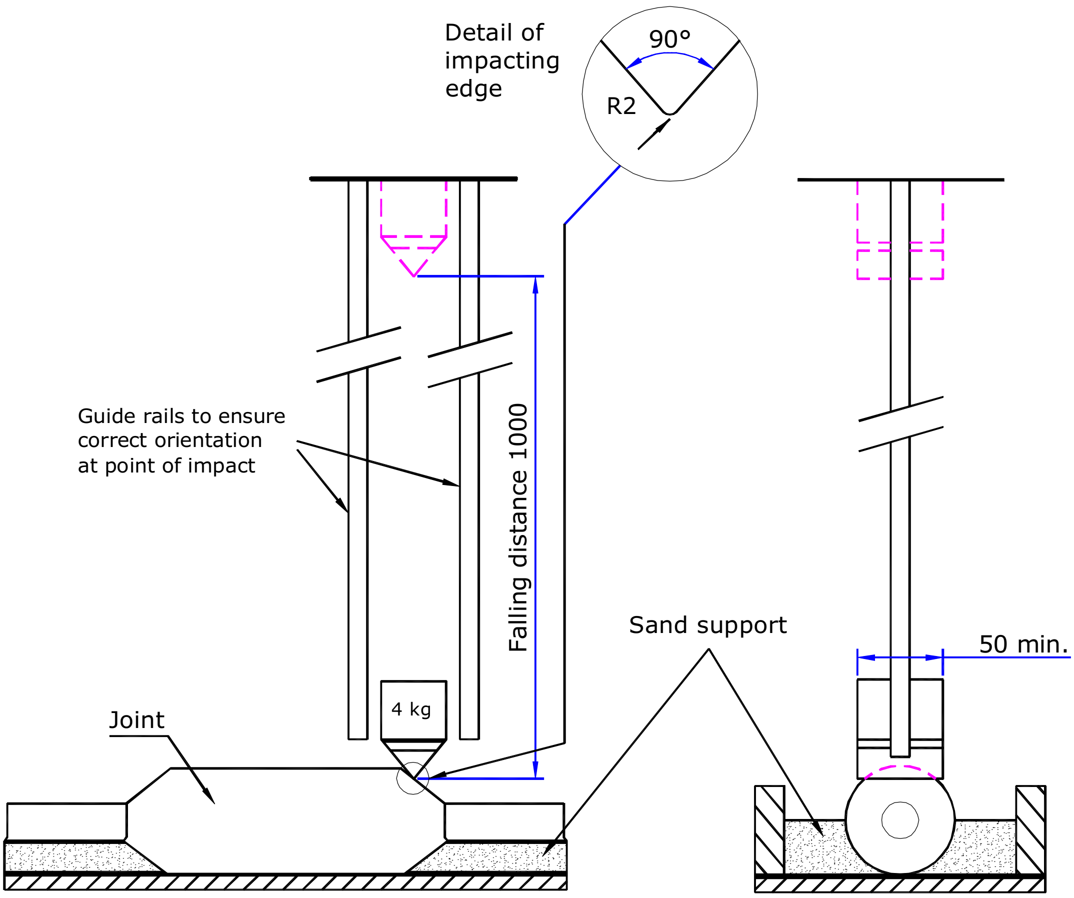


FIG. 8 TYPICAL IMPACT TEST APPARATUS FOR JOINTS

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 wrap around 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 **20.9** of IS 7098 (Part 3).

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 in position. 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 it's 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,

a) in the case of separable connectors with an earthed metal flange [*see* Fig. 9A], the metal foil shall be placed mid-way between the metal flange and the earth bond of the cable screen.

b) in the case of separable connectors without a metal flange [*see* Fig. 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 ohms as shown in Fig. 9.

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

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; and

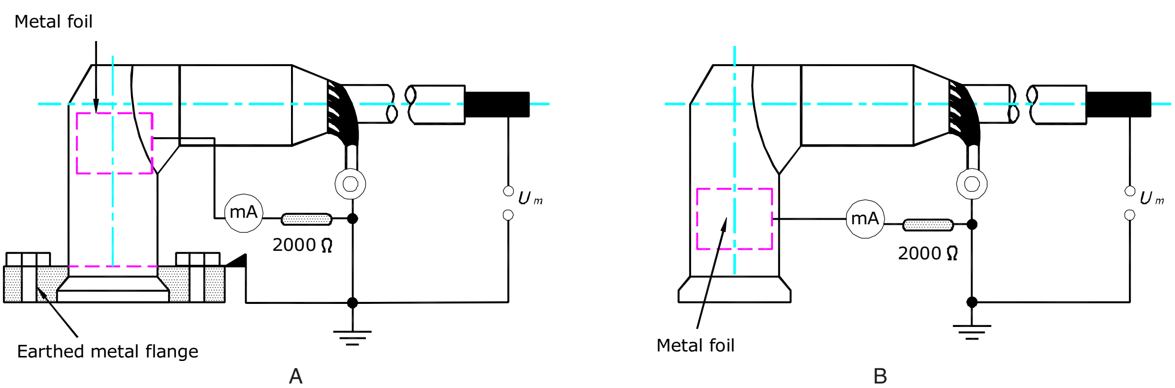


FIG. 9 TEST ARRANGEMENT FOR THE SCREEN LEAKAGE CURRENT MEASUREMENT

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 Fig. 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 Fig.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_o 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°C above its temperature prior to the first 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_o on the test specimen and a short circuit current of at least 10A.

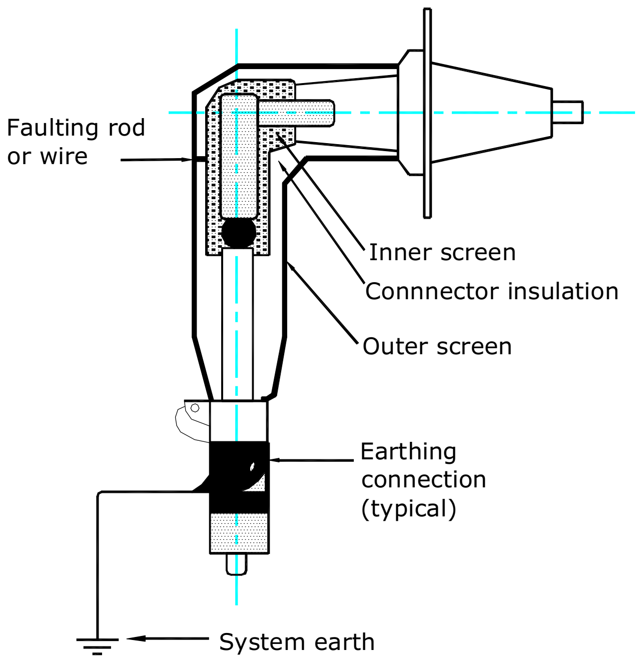


FIG. 10 TEST ARRANGEMENT FOR THE SCREEN FAULT CURRENT INITIATION TEST

The current for the short circuit test shall be agreed upon 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; and
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

This 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 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:

a) C_{tc} = capacitance between the test point and the cable conductor.
b) C_{te} = capacitance between the test point and the earth.

ANNEX A

(*Clauses* 8.2.1 *and* 8.2.2)

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°C to 10°C 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°C), 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 Fig. 11.

At each place, two thermocouples should be attached: one on the conductor (*a*), and one on the external surface (*b*), as shown in Fig. 12.

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).

NOTE — The thermocouples (*b*) on the external surface are only necessary, if method **A-3.2** is used.

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.

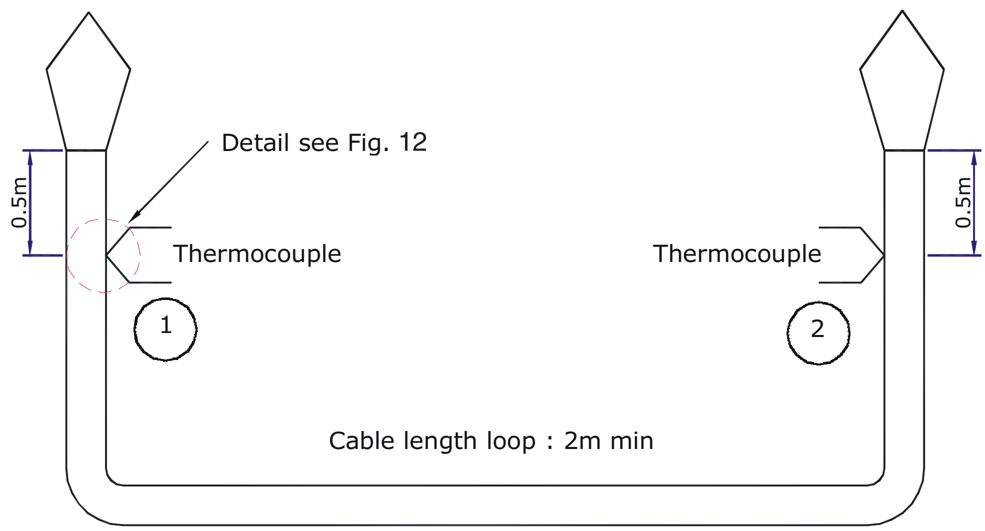


FIG. 11 REFERENCE CABLE

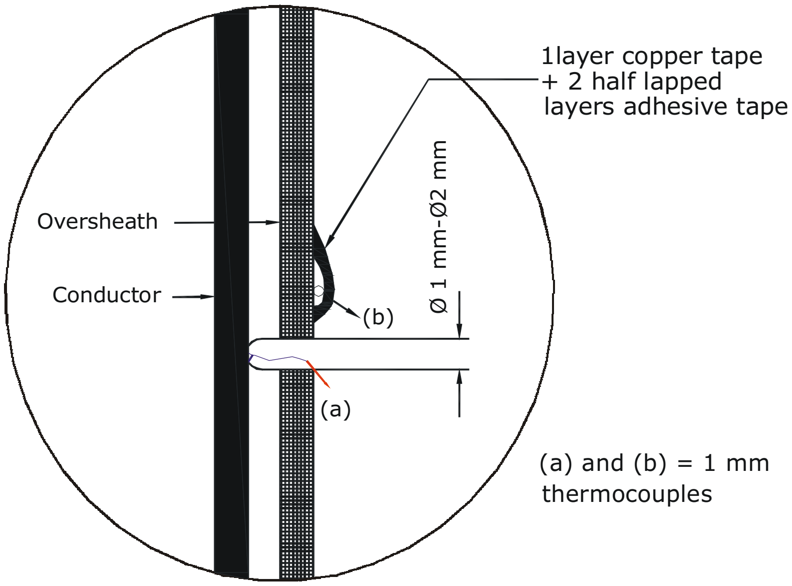


FIG. 12 ARRANGEMENT OF THE THERMOCOUPLES

The cable should be heated until the conductor temperatures a_1 and a_2, indicated by thermocouples (*a*) at positions 1 and 2 of Fig. 11, have stabilized and reached the temperatures between 5°C and 10°C above the maximum conductor temperature of the cable in normal operation, as given in the relevant standard for extruded insulation cables (*see* Fig. 12).

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°C within a 2 h period.

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

a) conductor temperature, $\theta_{cond} = (a_1 + a_2)/2$
b) sheath temperature, $\theta_{sheath.c} = (b_1 + b_2)/2$
c) ambient temperature, $\theta_{amb.c}$
d) heating current, I_{cal}

A-3 HEATING FOR ACCESSORY TEST

Let

R_{20} = resistance per unit length of conductor at 20°C (*see* IS 8130);

α_{20} = temperature coefficient of resistance at 20°C (*see* IS 8130);

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 surface of the cable (excluding T_4, the thermal resistance of air).

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

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

I_{test} = current during accessory test.

NOTE — $T' = T_1 + nT_2 + nT_3$ where $n = 1$ for single core cables; $n = 3$ for three core cables and $T = T' + n\,T_4$

A-3.1 Method 1 — Test Based on Measurement of Ambient Temperature

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

a) During cable calibration:

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

b) During accessory test:

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

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

Combining (1) and (2) gives:

$$I_{test} = I_{cal}\,\sqrt{\{(\theta_{cond} - \theta_{amb.t})/(\theta_{cond} - \theta_{amb.c})\}} \qquad \ldots(3)$$

A-3.2 Method 2 — Test Based on Measurement of the External Surface Temperature

a) During cable calibration:

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

b) During accessory test:

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

Combining (4) and (5) gives:

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

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:

$$\theta_{cond} = [\theta_{sheath.t} + (1 - 20\alpha_{20}) R_{20} I^2_{test} T'] / [1 - \alpha_{20} R_{20} I^2_{test} T'] \quad \ldots(7)$$

It is therefore possible to transpose this formula in the form of chart, as shown in Fig. 13, giving θ_{cond} from $\theta_{sheath.t}$ readings, for various values of the heating current I_{test1}, I_{test2}, …………..

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

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. The cable is not energized and therefore thermocouples can be fitted to the conductor as recommended in **A-2.1**.

The test arrangement should be such that,

a) the control cable should carry the same current as the test loop at any time, and
b) 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 Fig. 11, in the same way as the thermocouples are mounted on or under the surface of the control cable.

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.

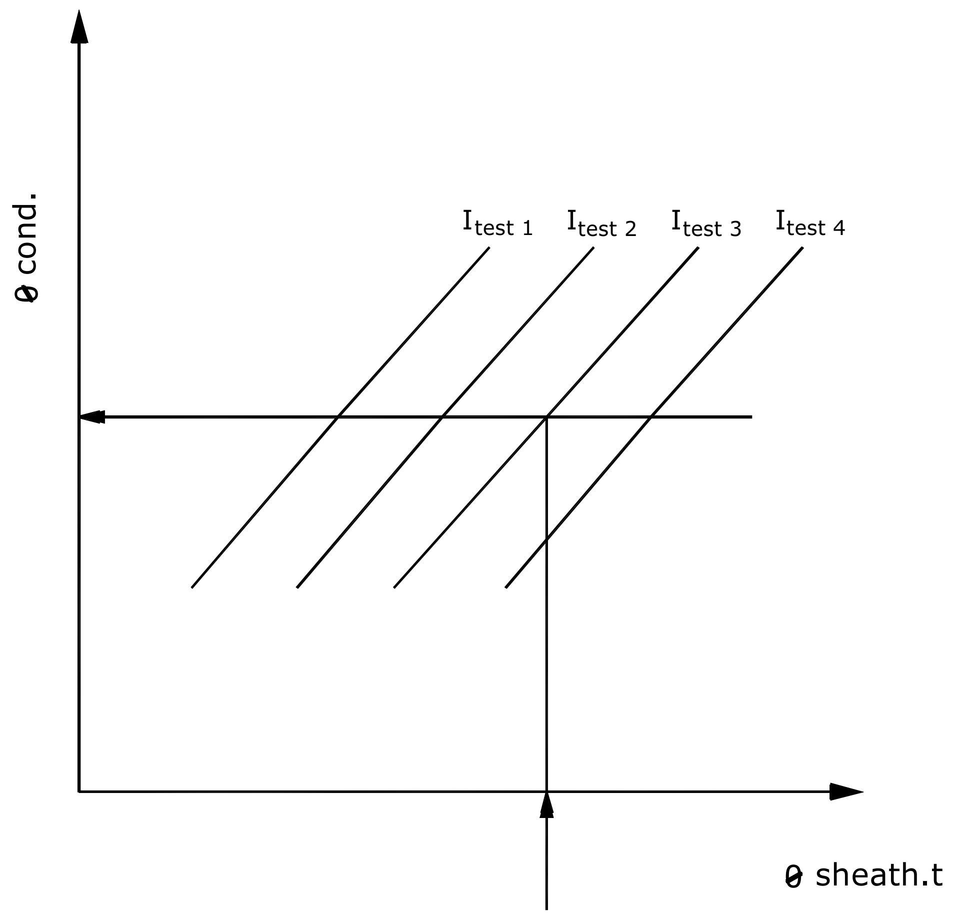


FIG. 13 CURRENT/TEMPERATURES CURVES

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 percent.

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

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.

ANNEX B

(*Clause*11.2)

MAXIMUM PERMISSIBLE SHORT CIRCUIT TEMPERATURE OF THE CABLE CONDUCTOR

B-1 MAXIMUM CONDUCTOR TEMPERATURES FOR DIFFERENT TYPES OF INSULATING COMPOUND

Sl No.	*Insulating Compound*	*Maximum Conductor Temperature* °C	
		Normal Operation	Short-Circuit (5 s Maximum Duration)
(1)	(2)	(3)	(4)
i)	Polyvinyl chloride (PVC/B):		
	a) Conductor cross-section ≤ 300 mm^2	70	160
	b) Conductor cross-section > 300 mm^2	70	140
ii)	Cross-linked polyethylene (XLPE)	90	250
iii)	Ethylene propylene rubber (EPR and HEPR)	90	250

ANNEX C

(*Clause* 13.1)

DETAILS OF THE TEST CHAMBER AND SPRAY EQUIPMENT FOR HUMIDITY AND SALT FOG TESTS

C-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.

C-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 IS 8704. 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 percent 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.

C-3 HIGH VOLTAGE TRANSFORMERS

For three phase testing, a three phase or three single phase transformer 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 should be possible to measure or calibrate the output voltage.

(*Continued from second cover*)

The joints and terminations of power *c*ables are normally made at site. For practical reasons, this standard is confined to type tests only. For tests at site, reference may be made to IS 1255 : 1983 'Code of practice for installation and maintenance of power cables up to and including 33 kV rating (*second revision*)'.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)' . The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices:		*Telephones*
Central :	Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
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