भारतीय मानक

Indian Standard

IS 18925 (Part 8) : 2024
IEC TS 62561-8 : 2018

विद्युत संरक्षण प्रणाली कम्पोनेंट्स (एलपीएससी)

भाग 8 पृथक एलपीएस के लिए कम्पोनेंट्स की अपेक्षाएँ

Lightning Protection System Components (LPSC)

Part 8 Requirements for Components for Isolated LPS

ICS 29.020; 91.120.40

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NATIONAL FOREWORD

This Standard (Part 8) which is identical to IEC TS 62561-8: 2018 'Lightning protection system components (LPSC) — Part 8: Requirements for components for isolated LPS' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electrical Installation Sectional Committee and approval of the Electrotechnical Division Council.

This Indian Standard is published in several parts. The other parts in this series are:

Part 1	Requirements for connection components
Part 2	Requirements for conductors and earth electrodes
Part 3	Requirements for isolating spark gaps ISGs
Part 4	Requirements for conductor fasteners
Part 5	Requirements for earth electrode inspection housings and earth electrode seals
Part 6	Requirements for lightning strike counters LSCs
Part 7	Requirements for earthing enhancing compounds

The text of the IEC standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appears referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to International Standards for which Indian Standards also exists. The corresponding Indian Standards, which are to be substituted, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60060-2 : 2010 High-voltage test techniques — Part 2: Measuring systems	IS/IEC 60060-2 : 2010 High-Voltage test techniques: Part 2 measuring systems	Identical
IEC 60068-2-75 : 2014 Environmental testing —Part 2: Tests–test Eh: hammer tests	IS 9000 (Part 7/Sec 7) : 2020 Environmental testing: Part 7 Tests, Section 7 Test Eh: hammer tests (*first revision*)	Identical
IEC 61083-1 Instruments and software used for measurement in high-voltage impulse tests — Part 1: Requirements for instruments	IS 15638 (Part 1) : 2006 Instruments and software used for measurement in high-voltage impulse tests: Part 1 Requirements for instruments	Identical

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CONTENTS

Indian Standard

LIGHTNING PROTECTION SYSTEM COMPONENTS (LPSC)
PART 8 REQUIREMENTS FOR COMPONENTS FOR ISOLATED LPS

1 Scope

This document specifies the requirements and tests for insulating stand-offs, used in conjunction with an air-termination system and down-conductors with the aim of maintaining the proper separation distance, and the requirements and tests for insulating down-conductors, including their specific fasteners, able to reduce the separation distance.

Testing of insulating stand-offs and insulating down-conductors components for an explosive atmosphere is not covered by this document.

Requirements and tests for other types of components for isolated LPS are under consideration.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-2:2010, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60068-2-52:2017, *Environmental testing – Part 2: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-75:2014, *Environmental testing –Part 2:Tests – Test Eh: Hammer tests*

IEC 61083-1, *Instruments and software used for measurement in high-voltage impulse tests – Part 1: Requirements for instruments*

IEC 61083-2, *Instruments and software used for measurement in high-voltage and high-current tests – Part 2: Requirements for software for tests with impulse voltages and currents*

IEC 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

IEC 62561-1:2017, *Lightning protection system components (LPSC) – Part 1: Requirements for connection components*

IEC 62561-2:2012, *Lightning protection system components (LPSC) – Part 2: Requirements for conductors and earth electrodes*

IEC 62561-4, *Lightning protection system components (LPSC) – Part 4: Requirements for conductor fasteners*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-3:2016, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

ISO 4892-4, *Plastics – Methods of exposure to laboratory light sources – Part 4: Open-flame carbon-arc lamps*

ISO 6988:1985, *Metallic and other non-organic coatings – Sulfur dioxide test with general condensation of moisture*

ISO 6957:1988, *Copper alloys – Ammonia test for stress corrosion resistance*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1
insulating stand-off
non-metallic or composite component, consisting of the insulator and fixation parts, designed to retain, support and insulate the air-termination system and/or down-conductors at a required separation distance

3.2
effective length correction factor
k_{x}
factor evaluating the different withstand voltage of air gaps and insulators under test voltages and environmental influences like pollution and/or UV light degradation

3.3
steepness correction factor for insulating stand-offs
c_{is_st}
factor considering the effect of higher steepness and the probability of occurrence of subsequent negative short strokes on the flashover voltage of an insulating stand-off

Note 1 to entry: The value is defined in the test procedure.

3.4
effective length of an insulating stand-off
l_{eff}
length (distance) of an air gap with equivalent break down behaviour to an insulating stand-off

3.5
corrected distance value of an insulating stand-off
l_{st}
shortest measured clearance distance between two conductive elements of different electrical potential, e.g. between a metallic conductor fastener and a mounting assembly

3.6
equivalent separation distance
s_{e}
corrected distance value to be used instead of the insulating length of a stand-off distance value equivalent to the separation distance of conventional down-conductors required in IEC 62305-3

3.7
down-conductor
conductor made of bare metal

3.8
insulating down-conductor
conductor provided with a layer of insulation with the purpose to reduce the separation distance

3.9
steepness correction factor for insulating down-conductors
c_{dc_st}
factor considering the effect of higher steepness and the probability of occurrence of subsequent negative short strokes on the withstand voltage of insulating down-conductors during testing

Note 2 to entry: The value is defined in the test procedure.

3.10
partial insulating down-conductor
conductor provided with a layer of insulation with the purpose to reduce the separation distance, supported by insulating stand-offs

3.11
clearance of the comparison arrangement
s_c
gap distance of the comparison arrangement used for verification of the effective length correction factor k_x and separation distance s_e

3.12
time to chopping
T_c
virtual parameter defined as the interval between the virtual origin and the instant of chopping

3.13
effective material insulating factor
k_m
coefficient of material, which depends on the electrical insulation material

Note 1 to entry: See IEC 62305-3.

3.14
installation arrangement
installation containing one or more insulating down-conductors and additional installation means (according to the manufacturer's instruction) to keep the defined separation distance and to support the insulating down-conductor mechanically

Note 2 to entry: One example is given in Figure F.1.

4 Insulating stand-off

4.1 Classification

4.1.1 General

Classification of the product depends on the withstand capability of mechanical forces.

4.1.2 According to conductor clamping arrangement

a) Conductor fasteners that are designed to clamp the conductor.

b) Conductor fasteners that are designed to clamp but allow axial movement of the conductor.

4.1.3 According to mounting

a) Free standing.

b) Rigidly fixed on a structure.

4.2 Requirements

4.2.1 General

An insulating stand-off shall retain, support and insulate the conductor when subjected to the stress of a lightning discharge under high impulse voltage and shall withstand the mechanical and environmental influences such as perpendicular and axial compression loads caused by the weight of the supported conductor along with snow, ice, wind and thermal expansion/contraction of the conductor.

An insulating stand-off shall be compatible with the conductor it is supporting and the surface to which it is fixed.

4.2.2 Construction

4.2.2.1 General

An insulating stand-off shall be so designed and constructed that:

– the surface is free from burrs, flash moulding, deformation and similar inconsistencies which are likely to inflict injury to the installer or user.

  Compliance is checked by visual inspection.

– it carries the perpendicular and axial compression loads caused by the weight of the supported conductor along with snow, ice, wind and thermal expansion/contraction of the conductor.

  Compliance is checked in accordance with 4.3.6.2 and 4.3.6.4.

4.2.2.2 Corrosion resistance

An insulating stand-off shall withstand the effects of corrosion typical of the environment to which it is exposed.

Compliance is checked by testing in accordance with 4.3.5.1.

4.2.2.3 UV light resistance

An insulating stand-off shall withstand the effects of UV exposure typical of the environment to which it is exposed.

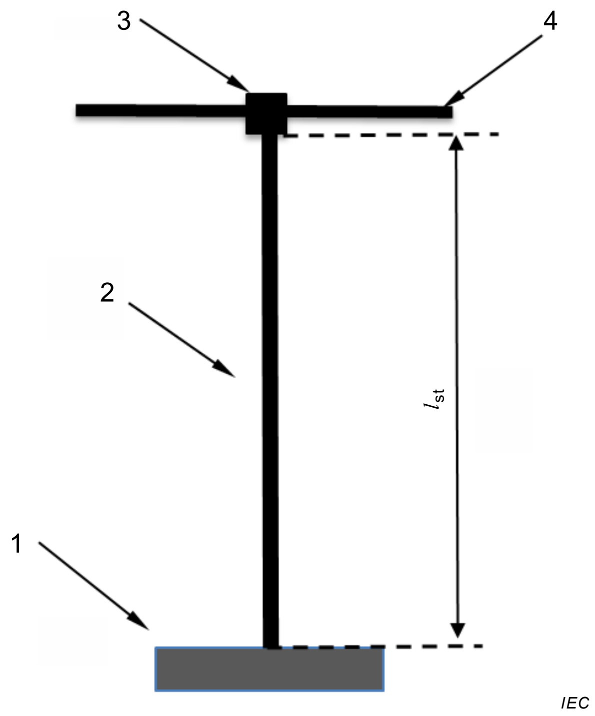
Compliance is checked by testing in accordance with 4.3.5.2.

4.2.3 Mechanical requirements

4.2.3.1 General

An insulating stand-off may consist of a mounting assembly, an insulator and a conductor fastener as shown in Figure 1 and/or Figure 2. The manufacturer of the insulating stand-off shall guarantee with appropriate mechanical tests or calculations that the stand-off fulfils the requirements stated in his documentation.

Compliance is checked by testing in accordance with 4.3.



Key

1 mounting assembly

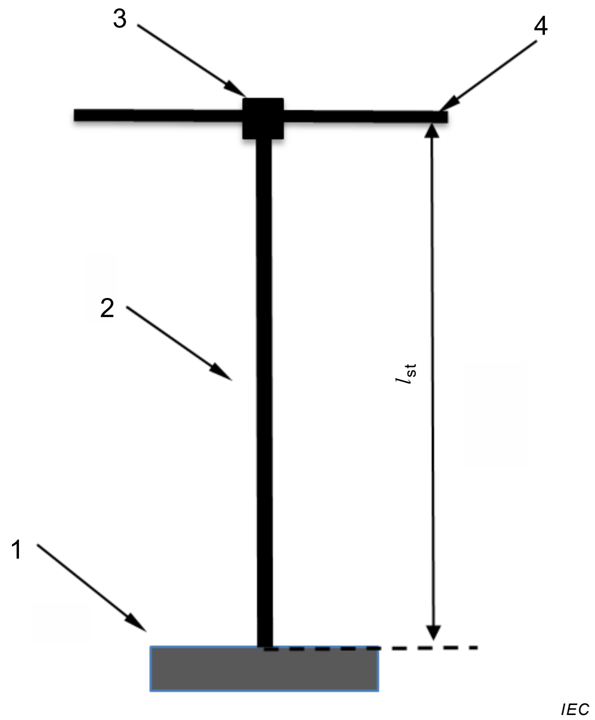
2 insulator

3 metallic conductor fastener

4 conductor

l_{st} insulating length

Figure 1 – Typical insulating stand-off with a metallic fastener



Key

1 mounting assembly

2 insulator

3 non-metallic conductor fastener

4 conductor

l_{st} insulating length

Figure 2 – Typical insulating stand-off with a non-metallic fastener

4.2.3.2 Mounting assembly

The mounting assembly which holds the insulator in position on the structure shall withstand mechanical stress.

Compliance is checked by testing in accordance with 4.3.6.

4.2.3.3 Insulator

The insulator shall withstand mechanical stress, e.g. pull out force, impact strength, bending load.

Compliance is checked by testing in accordance with 4.3.6.

4.2.3.4 Conductor fastener

The conductor fastener which is part of the insulating stand-off shall comply with the requirements and tests of IEC 62561-4.

4.2.4 Electrical requirements

An insulating stand-off shall be able to withstand the very high impulse voltages generated by a lightning strike.

An insulating stand-off has an insulating length l_{st} which is different from its effective length l_{eff}. The isolating capability of an insulating stand-off may be provided by either

a) its effective length l_{eff}, or
b) its effective length correction factor k_x.

The effective length correction factor k_x is determined from the effective length l_{eff} and the insulating length l_{st} as follows:

$$k_x = \frac{l_{eff}}{l_{st}}$$

The effective length l_{eff} is the value which shall be compared to the required separation distance s according to IEC 62305-3.This effective length of the insulating stand-off shall be equal to or greater than the required separation distance s.

Compliance is checked by testing in accordance with 4.3.1, 4.3.2 and 4.3.7.

For the purpose of calculating the separation distance as used in IEC 62305-3, the value k_m can be set equal to the value k_x.

NOTE Based on experience, a value of k_x = 0,7 for GFRP, PE and PVC insulating stand-offs under normal operating conditions has been found to be typical.

4.2.5 Documentation

The manufacturer or supplier of the insulating stand-off shall provide adequate information in the installation instructions to ensure that the installer can select and install the component in a suitable and safe manner in accordance with the requirements of IEC 62305-3.

Compliance is checked by inspection in accordance with 4.3.3.

4.2.6 Marking

An insulating stand-off shall be marked with:

a) the manufacturer's or responsible vendor's name, logo or trademark;
b) product identification or type.

Where it is not possible to make these marks directly onto the product, they shall be provided on the smallest supplied packaging.

NOTE Marking can be applied, for example, by moulding, pressing, engraving, printing, adhesive labels or water slide transfers.

Compliance is checked by testing in accordance with 4.3.4.

4.3 Tests

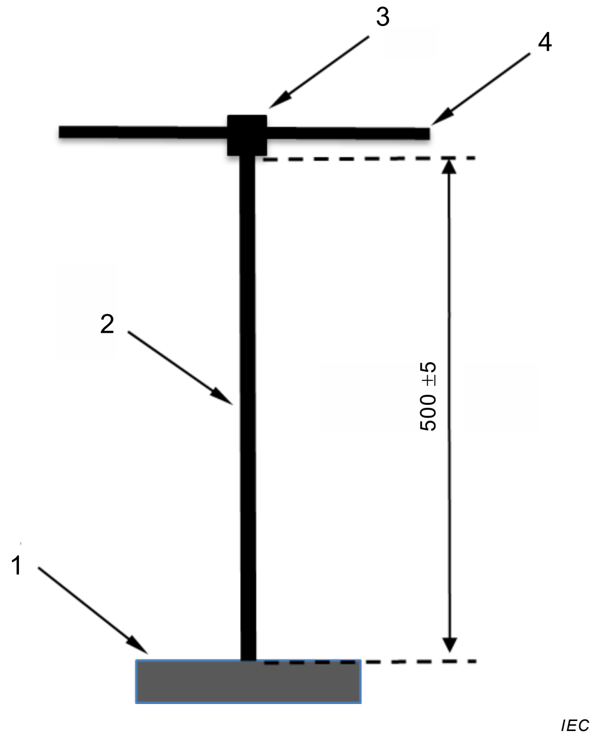
4.3.1 General test conditions

Tests according to this document are type tests. These tests are of such a nature that, after they have been performed, they need not be repeated unless changes are made to the materials, design or type of manufacturing process, which might change the performance characteristics of the insulating stand-off.

Unless otherwise specified, all tests are carried out with the specimens assembled and installed as in normal use according to the manufacturer's or supplier's instructions, using the recommended conductor materials, sizes and tightening torques.

The insulating length l_{st} of all specimens shall be (500 ± 5) mm unless otherwise specified in the relevant test procedure. The manufacturer shall prepare the test specimens according to Figure 3 and/or Figure 4.

Dimension in millimetres



Key

1 mounting assembly

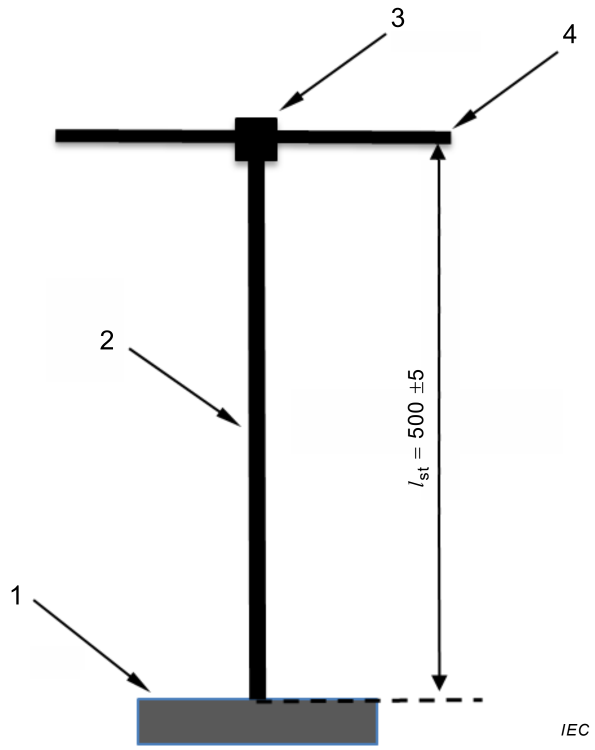
2 insulator

3 metallic conductor fastener

4 conductor

Figure 3 – Typical insulating stand-off with a metallic fastener prepared for testing

Dimension in millimetres



Key

1 mounting assembly

2 insulator

3 non-metallic conductor fastener

4 conductor

l_{st} insulating length

Figure 4 – Typical insulating stand-off with a non-metallic fastener prepared for testing

This document cannot cover all possible types of insulating stand-offs and the way of fixing them on various surfaces of different materials. When required for these applications, agreement should be obtained between the test engineer and manufacturer on the specific testing regime.

An insulating stand-off classified by the manufacturer in more than one of the classifications in 4.1 shall be tested for each applicable category.

Type tests are carried out on three specimens according to the test sequence indicated in Table 1. Within any test sequence, the tests shall be carried out in the order given in Annex C.

A specimen has passed a test sequence of Table 1 if all the requirements of the relevant test clauses and the relevant pass criteria have been fulfilled.

If the required number of specimens pass a test sequence, the design of the insulating stand-off is acceptable for that test sequence. If two or more test specimens fail a test sequence, the insulating stand-off does not comply with this document.

In the event that a single specimen does not pass a test, this test, and those preceding in the same test sequence that may have influenced the result of this test, shall be repeated with three new specimens. No failure of any specimen is allowed in the second sequence of tests. One set of three specimens may be used for more than one test sequence if agreed by the manufacturer.

The applicants, when submitting the first set of specimens may also submit an additional set of specimens that may be necessary should one specimen fail. The test house shall then, without further request, test the additional set of specimens and shall only reject if a further failure occurs. If the additional set of specimens is not submitted at the same time, a failure of one specimen shall entail rejection.

Tests shall not commence earlier than 168 h from the time of manufacture.

When not otherwise specified, the test shall be performed in free air, with an ambient temperature between +15 °C and +40 °C and relative humidity between 25 % and 75 %.

A torque meter having a resolution of at least 0,5 Nm and an accuracy of at least 4 % shall be used for all tightening operations.

NOTE Upon the instructions of the manufacturer, a set of specimens previously tested may also be suitable for use in other tests of this document as well.

Table 1 – Type test requirements for an insulating stand-off

Test sequence	Test description	Subclause	Identification of sets (one set consists of three specimens)	Number of specimens
1	Documentation	4.3.3	A	1
	Marking test	4.3.4	A	3
	Construction	4.3.6.1	A	3
	UV light test	4.3.5.2	B,C,D	9 or more due to surface deterioration during high voltage test.
	Corrosion test	4.3.5.1	A	3
	Pull out test	4.3.6.4	A	3
2	Bending test	4.3.6.2	B	3
	Impact test of the insulator	4.3.6.3	C	3
	Electrical test	4.3.7	D	3 or more due to surface deterioration during high voltage test.

4.3.2 General test setup

Unless otherwise specified by the manufacturer, the conductors and specimens shall be cleaned by using a suitable degreasing agent followed by cleaning in demineralized water and drying. They shall then be assembled according to the manufacturer's installation instructions, e.g. with the recommended conductors and tightening torques.

The tightening torque should be applied in a steady and uniform manner.

Any insulating stand-off accommodating a range of conductor diameters shall be tested on the minimum conductor size recommended.

4.3.3 Documentation

The manufacturer or responsible vendor shall provide the following in his literature:

a) the classifications according to 4.1;
b) the maximum and minimum conductor dimensions;
c) the conductor materials to be used;
d) the type of mounting surface to be fixed;
e) the recommended method of assembly, installation and fixing to the mounting surface;
f) the pull out force;
g) the bending force;
h) the mechanical strength (e.g. load torque, support load);
i) the k_x coefficient.

Compliance is checked by inspection.

4.3.4 Marking test

Marking on the product shall be durable and easily legible.

The durability of marking shall be tested by easy rubbing for ten times with a piece of cloth soaked with water.

Markings made by moulding, pressing or engraving are not subjected to this test.

Pass criteria:

The specimen is deemed to have passed the test if the marking remains legible.

Marking may be applied, for example, by moulding, pressing, engraving, printing, adhesive labels, etc.

4.3.5 Environmental influence tests

4.3.5.1 Corrosion test

An insulating stand-off with metallic components, including its conductor fastener and mounting assembly shall be subjected to environmental influence tests consisting of a salt mist test as specified in A.2 followed by a humid sulphurous atmosphere test as specified in A.3. An additional test by an ammonia atmosphere as specified in A.4 shall be carried out on an insulating stand-off having parts made of copper alloy with a copper content less than 80 %.

Pass criteria:

The specimens are deemed to have passed the test if no base metals of the metallic components show any corrosive deterioration visible to normal or corrected vision.

NOTE White rust, patina and surface oxidation are not considered as corrosive deterioration.

4.3.5.2 UV light test

The insulating part (insulator) of the insulating stand-off shall be subjected to an environmental test consisting of an ultraviolet light test as specified in Annex B.

The length of the test specimen shall be sufficient so that after the UV light test, a complete insulating stand-off can be assembled for further tests requiring an insulating length l_{st} of (500 ± 5) mm.

Pass criteria:

The specimens are deemed to have passed the test, if there are no signs of disintegration and cracks visible under normal or corrected vision.

4.3.5.3 Pollution test

This test is under consideration.

4.3.6 Mechanical tests

4.3.6.1 Construction

The surface of the insulating stand-off shall be free from burrs associated with the cutting process, moulding joint deformation and similar inconsistencies which are likely to inflict injury to the installer or user.

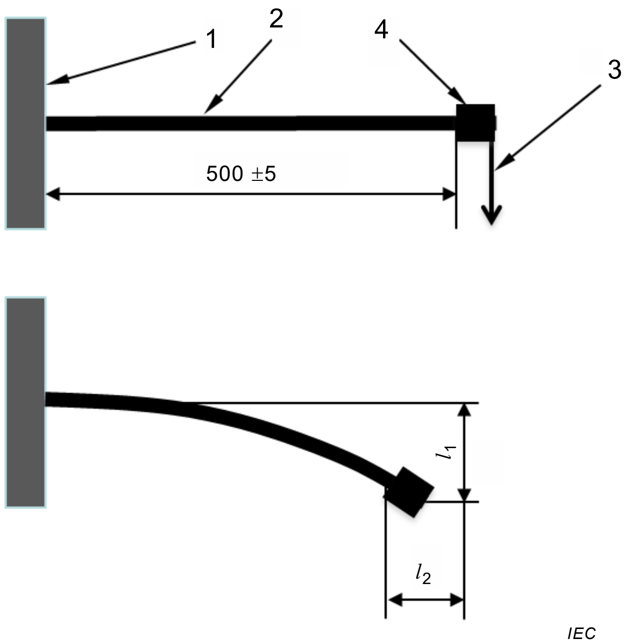
Compliance is checked by visual and manual inspection.

4.3.6.2 Bending test

Upon completion of the UV light test described in 4.3.5.2, one set of specimens shall be subjected to a bending test. A load declared by the manufacturer but not less than 10 N is applied at the end distant from the mounting as illustrated in Figure 5. The load shall be applied for a period of (60 ± 1) min.

Test samples may be used for 4.3.6.2 in case that the samples have fulfilled the pass criteria of the UV light test.

Dimension in millimetres



Key

1 mounting plate fixed on a solid wall (wall is not shown in drawing)

2 insulator

3 applied force

4 conductor fastener

l_1 deflection

l_2 reduction of safety distance

Figure 5 – Basic arrangement for bending test

All tests are carried out at a temperature of (−10 ± 1) °C and repeated at a temperature of (+40 ± 4) °C.

Pass criteria:

The specimens are deemed to have passed the test if the insulating stand-offs remain intact, show no cracks or similar damage visible to normal or corrected vision without magnification and the deflection l_1 is less than 10 % of the insulating length l_{st} and the reduction of the straight length by l_2 is less than 25 mm.

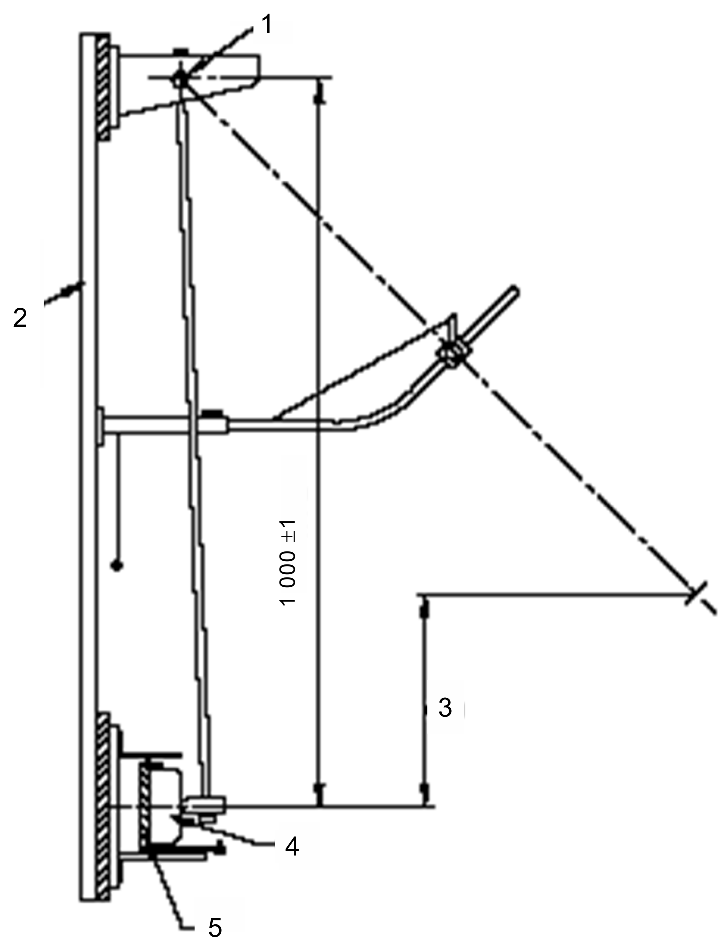
4.3.6.3 Impact test

This test is carried out on a section of the insulating stand-off with a length of (500 ± 5) mm.

After the UV light test of three specimens, the same specimens are subjected to an impact test.

Each specimen is mounted on a pendulum hammer test apparatus according to Clause 5 of IEC 60068-2-75:2014 as shown in Figure 6. The test apparatus is mounted on a solid wall or structure providing sufficient support.

Dimension in millimetres



Key

1 pendulum

2 frame

3 height of fall

4 specimen

5 mounting fixture

Figure 6 – Pendulum hammer test apparatus

As preconditioning, the specimen is placed in a cabinet at a temperature −5 °C for 2 h. The specimen is removed from the cabinet and immediately placed in position in the pendulum hammer test apparatus.

At (12 ± 2) s after removal of the specimen from the cabinet, the pendulum hammer test apparatus is allowed to fall (2 J, 0,5 kg, 400 mm). Three impacts are applied as perpendicular as possible to the specimen's length and at the midpoint of the insulator.

Alternatively, instead of placing the arrangements in a cabinet and applying the impact at (12 ± 2) s after removal of the specimen from the cabinet, it is allowable to apply the pendulum hammer inside a climatic chamber at a temperature of (−5 ± 1) °C after the specimens have been placed at this temperature for at least 2 h.

Pass criteria:

After the test, the specimens shall show no cracks or similar damage visible to normal or corrected vision without magnification.

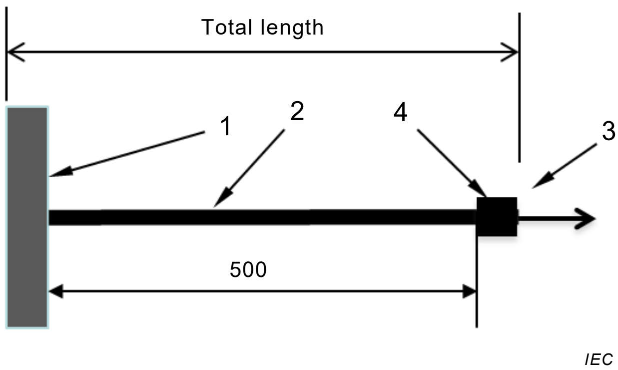
4.3.6.4 Pull out test

4.3.6.4.1 Insulating stand-off rigidly fixed on a structure

After the corrosion test in 4.3.5.1 a set of three specimens shall be subjected to a pull out force of 200 N at the conductor fastener end with the insulating stand-off secured at the mounting assembly as illustrated in Figure 7.

The force shall be applied for period of (60 ± 1) min. The fixing of the mounting assembly to the wall is not part of this test.

Dimension in millimetres



Key

1 mounting plate fixed on a solid wall (wall is not shown in drawing)

2 insulator

3 applied force

4 conductor fastener

Figure 7 – Basic arrangement for pull out test on rigidly fixed insulating stand-off

The total length of the insulator may be less than 500 mm as long as the test result is not influenced.

All tests are carried out at the temperature of (−10 ± 1) °C and repeated at the temperature of (+40 ± 4) °C).

Pass criteria:

The specimens are deemed to have passed the tests if the insulating stand-off remains intact and shows no cracks or similar damage visible to normal or corrected vision without magnification.

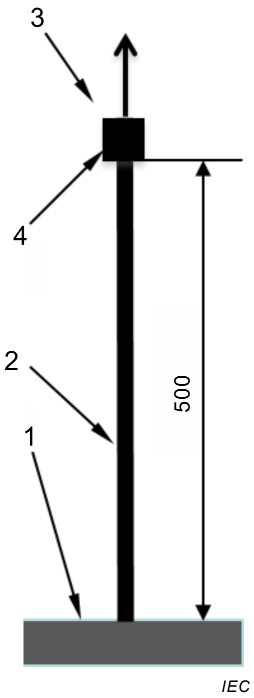
In addition there shall be no separation of individual parts and no axial movement exceeding 5 mm of the total length of the insulating stand-off.

4.3.6.4.2 Free standing insulating stand-off

After the corrosion test in 4.3.5.1, a set of three specimens shall be subjected to a pull out force with at least the weight of the stand-off's corresponding base but not more than 200 N at the conductor fastener end with the insulating stand-off secured at the base as illustrated in Figure 8.

The force shall be applied for period of (60 ± 1) min.

Dimension in millimetres



Key

1 mounting plate fixed on a floor (floor is not shown in drawing)

2 insulator

3 applied force

4 conductor fastener

Figure 8 – Basic arrangement for pull out test on free standing insulating stand-off

The total length of the insulator may be less than 500 mm as long as the test result is not influenced.

All tests are carried out at the temperature of (−10 ± 1) °C and repeated at the temperature of (+40 ± 4) °C.

Pass criteria:

The specimens are deemed to have passed the tests if the free standing insulating stand-off remains intact and shows no cracks or similar damage visible to normal or corrected vision without magnification.

In addition there shall be no separation of individual parts and no axial movement exceeding 5 mm of the total length of the free standing insulating stand-off.

4.3.7 Electrical test

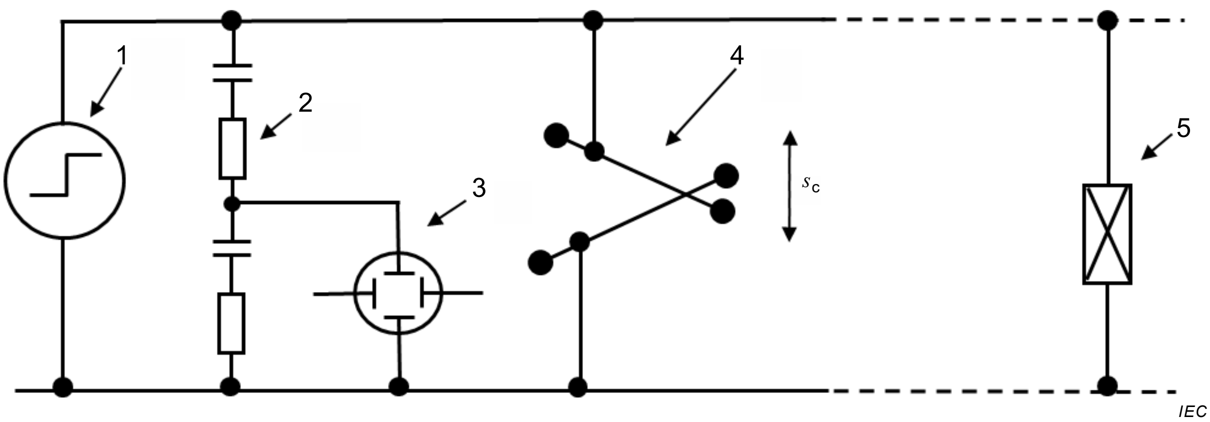
4.3.7.1 Specimen preparation

A UV light test shall be performed in accordance with 4.3.5.2 prior to the withstand voltage test.

One set of three specimens of the insulating stand-off with an insulating length l_{st} of (500 ± 5) mm shall be assembled according to the manufacturer's installation instructions.

4.3.7.2 Test setup

The electrical test is performed using the test arrangement given in Figure 9. For testing the withstand voltage of an insulating stand-off a comparison arrangement is used. The comparison arrangement uses a spark gap formed by two crossed rods above a conductive ground plane of 2 m × 2 m. These rods shall have a diameter of (8 ± 0,5) mm, and a length of at least 2 m. The minimum height of the grounded rod above the ground plane shall be at least 1,5 m. The distance between the specimen under test and the comparison arrangement shall be at least 2 m.



Key

1 high voltage impulse generator

2 high voltage impulse divider

3 impulse measuring device

4 comparison arrangement (spark gap)

5 specimen under test

s_c gap distance of the spark gap

Figure 9 – General description of the test arrangement for the high voltage impulse test of an insulating stand-off

The gap distance s_c of the spark gap in the comparison arrangement is used to verify the k_x coefficient declared by the manufacturer. Therefore the clearance dimension of the comparison arrangement shall be adjusted to:

$$s_c = \frac{500\,\text{mm} \cdot k_x}{c_{is\_st}} \,[\text{mm}]$$

NOTE 1 The factor c_{is_st} is defined as the effect of higher steepness and the probability of the occurrence of subsequent negative short strokes on the withstand voltage of insulating stand-offs compared to the test impulse. For a standard high voltage impulse (1,2/50 µs or faster) chopped at a time to chopping T_c = 1,2 µs, the steepness correction factor c_{is_st} can be assumed to be 0,97 for a dry insulating stand-off.

For the voltage measurement, a divider according to IEC 60060-2:2010, Clause 8 and a measuring instrument according to IEC 61083-1 and IEC 61083-2 shall be used.

NOTE 2 Impulse generators for negative subsequent short stroke induced voltages are not readily available. Therefore Marx generators, existing in almost all high voltage laboratories, are usually used for the high voltage impulse tests. Using Marx generators, a time to chopping of 1,0 μs to 1,4 μs can be achieved. This is accepted as a test value for induced voltages expected in first negative short strokes.

NOTE 3 To determine the actual correction factor k_x for insulating stand offs refer to Annex E.

4.3.7.3 Test procedure

The test shall be performed with impulse voltages of negative polarity only.

Before testing, the impulse generator shall be adjusted to a value U_t without the specimen under test being connected. The clearance dimension of the comparison arrangement shall be adjusted to s_c as detailed above.

The impulse generator shall be initially set without the specimen connected to a peak value approximating U_t = 500 kV and increased incrementally until the time to chopping T_c reaches the test condition of 1,0 μs < T_c < 1,4 μs.

NOTE Since the specimen under test is an additional load for the generator, a fitting procedure is to adjust the generator without the specimen under test close to 1,0 μs. There is no need to verify the time to half-value of the impulse. If the condition 1,0 μs < T_c < 1,4 μs cannot be met, the damping resistors of the Marx generator are reduced in order to increase the steepness and the amplitude of the applied voltage.

After U_t has been adjusted, the test specimen shall be connected to the impulse generator as shown in Figure 9. The test specimen is then tested with three impulses of U_t and T_c. All three impulses shall be recorded.

Pass criteria:

The specimens have passed the test if all three impulses cause a flashover only on the comparison arrangement within 1,0 μs < T_c < 1,4 μs for all three specimens. In case there is simultaneous flashover on both specimen under test and the comparison arrangement, repeat the test.

If the test condition for T_c is not fulfilled, the test may be repeated with an impulse voltage increased by 5 % until the test condition for T_c is fulfilled.

4.4 Electromagnetic compatibility (EMC)

Products covered by this document are, in normal use, passive with respect to electromagnetic influences (emission and immunity).

4.5 Structure and content of the test report

4.5.1 General

The purpose of this instruction is to provide general requirements for laboratory test reports. This document is intended to promote clear, complete reporting procedures for laboratories submitting test reports.

The results of each test carried out by the laboratory shall be reported accurately, clearly, unambiguously and objectively, in accordance with any instructions in the test methods. The results shall be reported in a test report and shall include all the information necessary for the interpretation of the test results and all information required by the method used.

Particular care and attention shall be paid to the arrangement of the report, especially with regard to presentation of the test data and ease of assimilation by the reader. The format shall be carefully and specifically designed for each type of test carried out, but the headings shall be standardized as indicated herein.

The structure of each report shall include at a minimum the information listed in 4.5.2 to 4.5.4.6.

4.5.2 Report identification

a) A title or subject of the report.
b) Name, address and telephone number of the designated test laboratory: name, address and telephone number of any sub testing laboratories where tests were carried out, if different from the designated test laboratory company which has been assigned to perform the testing.
c) Unique identification number (or serial number) of the test report.
d) Name and address of the vendor.
e) The report shall be paginated and the total number of pages indicated on each page including appendices or annexes.
f) Date of issue of the report.
g) Date(s) of performance of test(s).
h) Signature and title, or equivalent identification of the person(s) authorized to sign for the designated testing laboratory responsible for the content of the report.
i) Signature and title of person(s) conducting the test(s).
j) Declaration to avoid misuse.

The following declaration shall be included in the test report in order to avoid misuse.

"This type test report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory. This type test report covers only the specimens submitted for test and does not provide evidence of the quality for a similar series of items or products."

4.5.3 Specimen description

a) Specimen description.
b) Functional parts and accessories description (e.g. screws, nuts, washers, quantity, material, etc.).
c) Detailed description and unambiguous identification of the test specimen and/or test assembly.

4.5.4 Characterization and condition of the test specimen and/or test assembly

4.5.4.1 Insulating stand-off

a) Conductor fastener material.
b) Declared bending force applied during the test.
c) Nominal cross-section area, dimensions and shape of the insulator. The actual cross-sectional area should also be given.
d) Insulator material.
e) Material of the mounting assembly.

4.5.4.2 Standards and references

a) Identification of the test standard (Technical Specification) used and the date of issue of the standard (Technical Specification);
b) Reference to this document may be made only if the full set of tests is performed and reported except where the deviations are clearly justified in 4.5.4.3.
c) Other relevant documentation with the documentation date.

4.5.4.3 Test procedure

a) Description of the test procedure.

b) Justification for any deviations, additions to or exclusions from the referenced standard (Technical Specification).
c) Any other information relevant to a specific test such as environmental conditions.
d) Configuration of testing assembly.
e) Location of the arrangement in the testing area and measuring techniques.

4.5.4.4 Testing equipment, description

Description of equipment used for every test conducted, i.e. generator, conditioning/ageing device.

4.5.4.5 Measuring instruments description

a) Characteristics and calibration date of all instruments used for measuring the values specified in the Technical Specification, i.e. shunts, oscilloscope, ohmmeter, torque meter.
b) The dynamic behaviour for the high voltage divider used shall be fully documented. The parameters of the response according to IEC 60060-2:2010, Annex C shall be fully documented.

4.5.4.6 Results and parameters recorded

a) The required passing criteria for each test, defined by the Technical Specification.
b) The relevant observed or derived results of the tests.
c) All results shall be presented by tables, graphs, oscillograms, drawings, photographs or other documentation of visual observations as appropriate.
d) A statement of pass/fail identifying the part of the test for which the specimen has failed and also a description of the failure.
e) Environmental conditions before and after the test.

5 Insulating down-conductor

5.1 Classification

Classification of insulating down-conductors depends on the lightning current carrying capabilities.

The selection of classes H_2, H_1, H and N should be performed by the manufacturer in accordance with the test parameters identified in Table 2.

Fasteners for insulating down-conductors are classified as follows.

a) According to material:
   – metallic (e.g. hot dip galvanized steel, copper, aluminium, stainless steel);
   – non-metallic (e.g. PVC, plastics);
   – composite (combination of metal and plastic);
b) According to the fixing arrangement of the insulating down-conductor and the fastener:
   – with screws;
   – without screws (e.g. clips, springs).

5.2 Lightning current carrying capability

Table 2 – Lightning impulse current (I_{imp}) parameters

Classification	I_{imp} kA ± 10 %	W/R kJ/Ω ± 35 %
N	50	625
H	100	2 500
H_1	150	5 600
H_2	200	10 000
NOTE The parameters specified in Table 2 can typically be achieved by an exponentially decaying lightning impulse current having a time to half value in the range of 350 µs according to IEC 62305-1.		

5.3 Preferred values of equivalent separation distance s_e

s_e 25 cm, 50 cm, 75 cm, 100 cm

NOTE Preferred values mean values which are often used in practice. Depending on real conditions, lower and in some cases higher values may be needed.

5.4 Requirements

5.4.1 General

An insulating down-conductor shall carry out its function of insulating the conductor in an acceptable and safe manner when subjected to lightning discharge stress, mechanical influences and environmental influences. It shall be so designed and constructed that safe handling is ensured.

An insulating down-conductor shall be provided with dedicated fasteners to fix it to the surface of the structure to be protected without damage to the conductor or insulation.

An insulating down-conductor shall be compatible with the surface material to which it is fixed and comply with the tests given in 5.5.

5.4.2 Environmental requirements

5.4.2.1 Corrosion resistance

The metallic parts of an insulating down-conductor system, including conductor fasteners, terminations, and connector components, shall withstand the effects of corrosion typical of the environment to which it is exposed.

Compliance is checked following the manufacturer’s declaration for the classification of the insulating down-conductor by testing according to 5.5.5.1.

5.4.2.2 UV light test

The non-metallic portion of insulating down-conductor, conductor fasteners, terminations and connection components shall withstand the effects of UV light typical of the environment to which it is exposed.

Compliance is checked by testing in accordance with 5.5.5.2.

5.4.3 Mechanical requirements

An insulating down-conductor shall fulfil the requirements of IEC 62561-2. Deviation from the requirements given in Table 1 of IEC 62561-2:2012 shall be acceptable as long as the insulated down-conductor passes the electrical test specified in 5.5.7.

5.4.4 Electrical requirements

5.4.4.1 General

An insulating down-conductor shall be able to withstand the actual stress generated by a lightning stroke associated with the LPL declared by the manufacturer.

5.4.4.2 Lightning current carrying capability

An insulating down-conductor shall have sufficient lightning current carrying capability.

All connectors needed to assemble an insulating down-conductor shall comply with IEC 62561-1.

The test specified in 5.5.7.1 is required for insulating down-conductors if their metallic conductor has less cross sectional area than standardized in IEC 62561-2 or if they are intended to carry more current (I_{imp}) than 100 kA.

Compliance is checked according to the manufacturer's declaration of the lightning current carrying capability by tests specified in 5.5.7.1.

5.4.4.3 Equivalent separation distance s_{e}

Insulating down-conductors shall be able to withstand the very high impulse voltages generated by a lightning strike.

An insulating down-conductor shall have an equivalent separation distance s_{e} which is equal to or greater than the required separation distance specified in IEC 62305-3.

Compliance is checked according to the manufacturer's declaration of the equivalent separation distance for the classification of the insulating down-conductor in accordance with 5.1 and by the test specified in 5.5.7.

For additional installation means (installation arrangement) as defined in 3.14, compliance of the equivalent separation distance for each installation arrangement described in the documentation should be checked by the installation arrangement test specified in Annex F.

5.4.5 Documentation

The manufacturer or supplier of the insulating down-conductor shall provide adequate information in their documentation to ensure that the installer can select and install the component in a suitable and safe manner in accordance with requirements of IEC 62305-3.

Compliance is checked by inspection in accordance with 5.5.3.

Installation means supporting insulating down-conductors have to be tested in combination with the down-conductors. Additionally the high voltage installation arrangement test is recommended as described in Annex F. Each installation arrangement described in the installation instructions has to be tested separately.

5.4.6 Marking

Each insulating down-conductor shall be marked at least every 3 m with:

a) the manufacturer's or responsible vendor's name, logo or trademark;
b) product identification or type;
c) equivalent separation distance s_e;
d) current I_{imp}.

Where it is not possible to make these marks directly onto the product, they shall be on the smallest supplied packaging.

NOTE Marking may be applied, for example, by moulding, pressing, engraving, printing, adhesive labels or water slide transfers.

Compliance is checked by testing in accordance with 5.5.3.

5.5 Tests

5.5.1 General test conditions

Tests according to this document are type tests. These tests are of such a nature that, after they have been performed, they need not be repeated unless changes are made to the materials, design or type of manufacturing process, which might change the performance characteristics of the insulating down-conductor.

The document cannot cover all possible types of insulating down-conductor and the way of fixing them on various surfaces of different materials. When required, for these applications, agreement should be obtained between the test engineer and manufacturer on the specific testing regime.

Unless otherwise specified, all tests are carried out with the specimens assembled and installed for normal use according to the manufacturer's or supplier's instructions, with the recommended conductor materials, sizes and tightening torques.

If an insulating down-conductor is classified by the manufacturer in more than one of the classifications in 5.1, only the highest classification has to be tested.

Type tests are carried out on three specimens according to the test sequence specified in Table 3. Within any test sequence, the tests shall be carried out in the order given in Annex D.

A specimen has passed a test sequence of Table 3 if all the requirements of the relevant test clauses and the relevant pass criteria are fulfilled.

If the required number of specimens pass a test sequence, the design of the insulating down-conductor is acceptable for that test sequence. If two or more test specimens fail a test sequence, the insulating down-conductor does not comply with this document.

In the event that a single specimen does not pass a test, this test (and the prior testing required by the test sequence that may have influenced the result of the failed test) shall be repeated with three new specimens. No failure of any specimen is allowed in the second sequence of tests. A set of three specimens may be used for more than one test sequence when agreed by the manufacturer.

The applicant, when submitting the first set of specimens may also submit an additional set of specimens that may be necessary should one specimen fail. The test house shall, without further authorization, test the additional set of specimens, and shall only reject the product if an additional failure occurs. If the additional set of specimens is not submitted, a failure of one specimen of the first set shall cause product rejection.

Tests shall not commence earlier than 168 h from the time of manufacture.

When not otherwise specified, the test shall be performed in free air, with an ambient temperature between +15 °C and +40 °C and relative humidity between 25 % and 75 %.

A torque meter having a resolution of at least 0,5 Nm and an accuracy equal to or less than ±4 % shall be used for all tightening operations.

The accuracy for all other mechanical loads applied to the test specimen shall be equal to or less than ±5 %.

Table 3 – Type test requirements for an insulating down-conductor and fasteners

Test sequence	Test description	Sub-clause	Identification of sets (one set consists of 3 specimens)	Number of specimens
1	Documentation	5.4.5	A	1
	Marking test	5.5.4	A	1
	Construction	5.5.6.1	A	1
2	Metallic and composite fasteners			
	Corrosion test	5.5.5.1	A, B, F	9
	Lateral load test	5.5.6.2.1	A	3
	Axial movement test	5.5.6.3	B	3
3	Non-metallic and composite fasteners			
	UV light test	5.5.5.2	C,D,E	9
	Lateral load test	5.5.6.2.2	C	3
	Axial movement test	5.5.6.3.3	D	3
	Impact test	5.5.6.3.4	E	3
4	Lightning current carrying capability test	5.5.7.1	F	3
	High voltage impulse test	5.5.7.2	F	3

5.5.2 General test setup

Unless otherwise specified by the manufacturer, the insulating down-conductor system shall be cleaned by using a suitable degreasing agent followed by cleaning in demineralized water and drying. The specimen shall then be assembled according to the manufacturer's installation instructions, e.g. with the recommended connectors at the specified tightening torques.

The tightening torque should be applied in a steady and uniform manner.

Testing the equivalent separation distance of the insulating conductor system requires the complete working system which normally consists of an insulating conductor, cable fasteners providing a means of attachment to the mounting surface and connector fittings designed to connect and support air terminals at the required distance. Therefore the complete system shall be tested.

5.5.3 Documentation

The manufacturer or responsible vendor shall provide in his literature:

a) the classifications according to 5.1;
b) the conductor dimensions;
c) materials to be used with the insulating conductor;
d) the type of mounting surface to be fixed;
e) the recommended method of assembly, installation and fixing to the mounting surface;
f) the equivalent separation distance s_e;
g) information for flame retardant and smoke density of insulating conductors suitable for installation inside the structure according to IEC 60332-3 and IEC 61034.

Compliance is checked by inspection.

5.5.4 Marking test

The durability of marking shall be tested by easy rubbing for 10 times with a piece of cloth soaked with water.

5.5.5 Environmental influence tests

5.5.5.1 Corrosion test

This test is performed as preconditioning prior to the electrical testing specified in 5.5.7.1. Three specimens of the insulating down-conductor with terminations shall be assembled as shown in Figure 13 in accordance with the manufacturer's installation instructions, (e.g. with the recommended conductor fasteners and connector terminals installed to the tightening torques specified by the manufacturer).

The specimens shall be subjected to the environmental influence tests specified in Annex A consisting of a salt mist test specified in A.2 followed by a humid sulphurous atmosphere test specified in A.3. The additional test for ammonia atmosphere specified in A.4 shall be carried out for conductor fasteners and connectors made of copper alloys having copper content of less than 80 %. Subclause 5.5.5.1 and A.4 are also applicable for conductor fasteners and connectors having any component parts made of copper alloys with copper content of less than 80 %.

The specimens are deemed to have passed the tests if there are no signs of corrosive deterioration of the insulating conductor, conductor fasteners, or connectors visible to normal or corrected vision.

NOTE 1 The corrosion test as described in 5.5.5.1 follows IEC 62561-4 modified in a way that the special conditions for insulating down-conductors including their connectors are taken into account.

NOTE 2 White rust, patina and surface oxidation are not considered as corrosive deterioration.

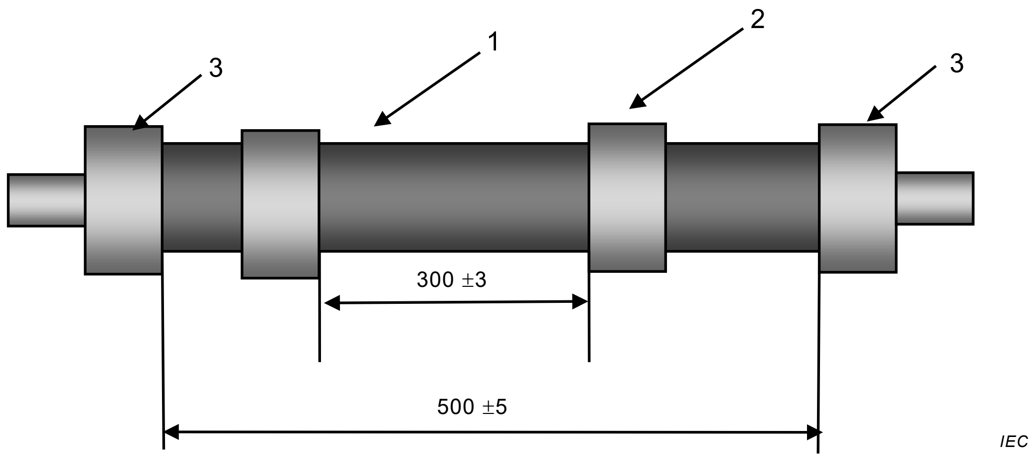
5.5.5.2 Ultraviolet (UV) light test

5.5.5.2.1 Sample preparation

One set of three sections of insulating down-conductors equipped with the cable fasteners, measurement contacts, terminations and connector components specified by the manufacturer shall be prepared for the UV light test shown in Figure 10, as specified in Annex B.

If the insulating down-conductor is intended to be used with non-metallic fasteners, the manufacturer shall provide appropriate metal contacts for the measurement of the electrical resistance.

Dimensions in millimetres



Key

1 section of insulating down-conductor

2 metallic fasteners or measurement contacts

3 terminals or connection components

Figure 10 – Specimen preparation for UV light test

5.5.5.2.2 Test procedure

Prior to and after the UV light test the electrical resistance between the two metallic fasteners (metallic contacts) shown in Figure 10 shall be measured with a voltage-current measurement device at a DC test voltage > 50 V in both polarities. Three measurements shall be performed 10 s after application of the DC voltage at a temperature of (20 ± 4) °C.

It is recommended to verify the torque of the screws prior to and after the UV light test.

The specimens shall be subjected to the UV light test specified in Annex B.

Pass criteria:

The specimens are deemed to have passed this test if:

a) the change of the average resistance for each polarity prior to and after the UV light test is less than 50 % of the initial value;
b) there are no signs of disintegration and no cracks visible to normal or corrected vision.

5.5.6 Mechanical tests

5.5.6.1 Construction

The surface of the insulating down-conductor and associated components shall be free from burrs from the cutting process, moulding joint deformation and similar inconsistencies which are likely to damage the conductors or inflict injury to the installer or user.

Compliance is checked by visual and manual inspection.

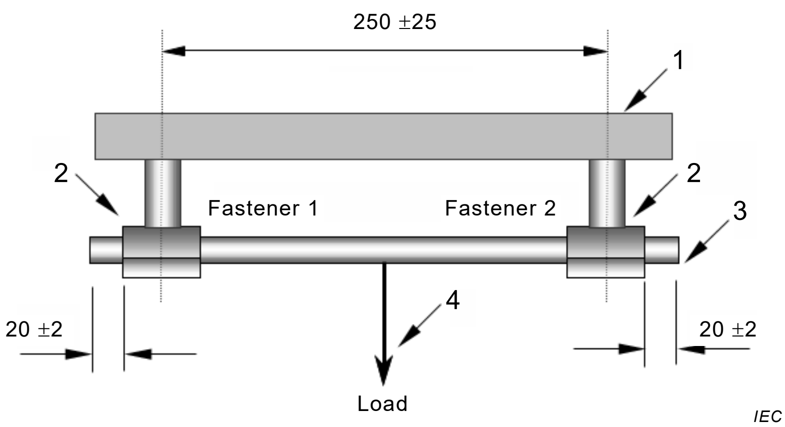
5.5.6.2 Lateral load test of cable fasteners for insulating down-conductors

5.5.6.2.1 Metallic or composite cable fasteners

As preconditioning, the corrosion test according to 5.5.5.1 and the UV light test, only for composite fasteners, specified in 5.5.5.2 shall be performed on each specimen.

A set of three specimens is subjected to a load test of 200 N applied at the midpoint distance between the fasteners as illustrated in Figure 11.

Dimensions in millimetres



Key

1 mounting plate

2 fastener

3 insulating down-conductor

4 load

Figure 11 – Basic arrangement for lateral load test

The full test load is applied for a period of 5 min to 6 min.

All tests are carried out at a temperature of (−10 ± 1) °C and repeated at a temperature of (+40 ± 4) °C.

Pass criteria:

The specimens have passed the test provided the fasteners remain intact and the insulating conductor is undamaged and not pulled within the cable fastener ends.

5.5.6.2.2 Non-metallic or composite cable fasteners

As preconditioning the UV light test specified in 5.5.5.2 shall be performed on each specimen.

A set of three specimens is subjected to a load test of 200 N applied at the midpoint distance between the fasteners as illustrated in Figure 11.

The full test load is applied for a period of 60 min to 61 min.

All tests are carried out at a temperature of (−10 ± 1) °C and repeated at a temperature of (+40 ± 4) °C.

Pass criteria:

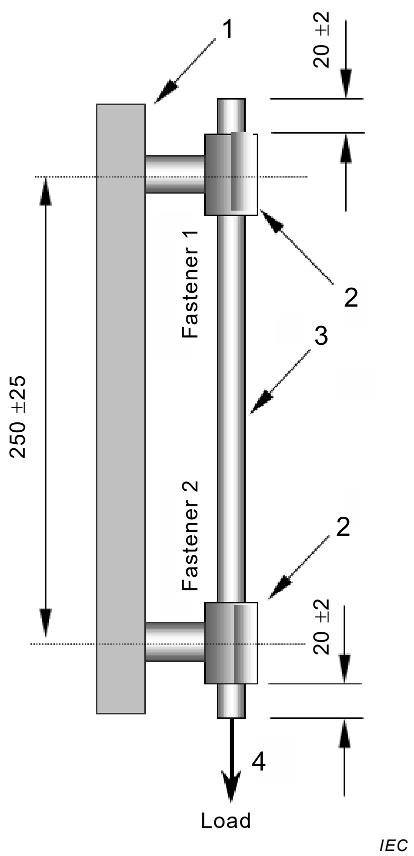
The specimens have passed the test provided the fasteners remain intact and the insulating conductor is undamaged and not pulled within the cable fastener ends.

5.5.6.3 Axial movement test of cable fasteners for insulating down-conductors

5.5.6.3.1 Test setup

The test is performed on an insulating down-conductor with a minimum length of 300 mm where the fasteners are mounted at a distance of (250 ± 25) mm as shown in Figure 12.

Dimensions in millimetres



Key

1 mounting plate

2 fastener

3 insulating down-conductor

4 load

Figure 12 – Typical arrangement for axial movement test

5.5.6.3.2 Metallic cable fasteners

As preconditioning the corrosion test specified in 5.5.5.1 shall be performed on each specimen.

A set of three specimens is subjected to a load test of 50 N applied as shown in Figure 12.

The full test load is applied for a period of 5 min to 6 min.

All tests are carried out at a temperature of (−10 ± 1) °C and repeated at a temperature of (+40 ± 4) °C.

Pass criteria:

The specimens have passed the test provided the fasteners remain intact, the insulating conductor is undamaged, and the displacement of the insulating conductor with respect to the fasteners is not more than 3 mm.

5.5.6.3.3 Non-metallic or composite cable fasteners

As preconditioning the UV light test specified in 5.5.5.2 shall be performed on each specimen.

A set of three specimens is subjected to a load test of 50 N applied as shown in Figure 12.

The full test load is applied for a period of 60 min to 61 min.

All tests are carried out at a temperature of (−10 ± 1) °C and repeated at a temperature of (+40 ± 4) °C.

Pass criteria:

The specimens have passed the test provided the fasteners remain intact, the insulating down-conductor is undamaged and the displacement of the insulating down-conductor with respect to the conductor fasteners is not more than 3 mm.

5.5.6.3.4 Impact test

The test is carried out on a (500 ± 5) mm length of insulating down-conductor with two, non-metallic or composite cable fasteners mounted at one of the conductor specimen.

The UV light test specified in 5.5.5.2 shall be performed as preconditioning for this test.

Three specimens shall be subjected to the impact test.

Each specimen is mounted on a pendulum hammer test apparatus according to Clause 5 of IEC 60068-2-75:2014, as shown in Figure 6.The test apparatus is mounted on a solid wall or structure providing sufficient support.

The specimen shall be placed in a cabinet at a temperature of −5 °C for 2 h. The specimen is removed from the cabinet and immediately placed in position in the pendulum hammer test apparatus.

At (12 ± 2) s after removal of the specimen from the cabinet, the hammer is allowed to fall (2 J, 0,5 kg, 400 mm) so that three impacts are applied as perpendicular as possible to the length axis of the insulating conductor.

The first impact should be to the left fastener, the second to the right fastener, and the third to the midpoint on the insulating down-conductor between fasteners.

Alternatively, it is allowable to apply the pendulum hammer test apparatus inside a climatic chamber after the specimen is held at a temperature of −5 °C (± 1 °C) for a minimum of 2 h.

Pass criteria:

After the test the specimens shall show no cracks or similar damage visible to normal or corrected vision without magnification.

5.5.7 Electrical tests

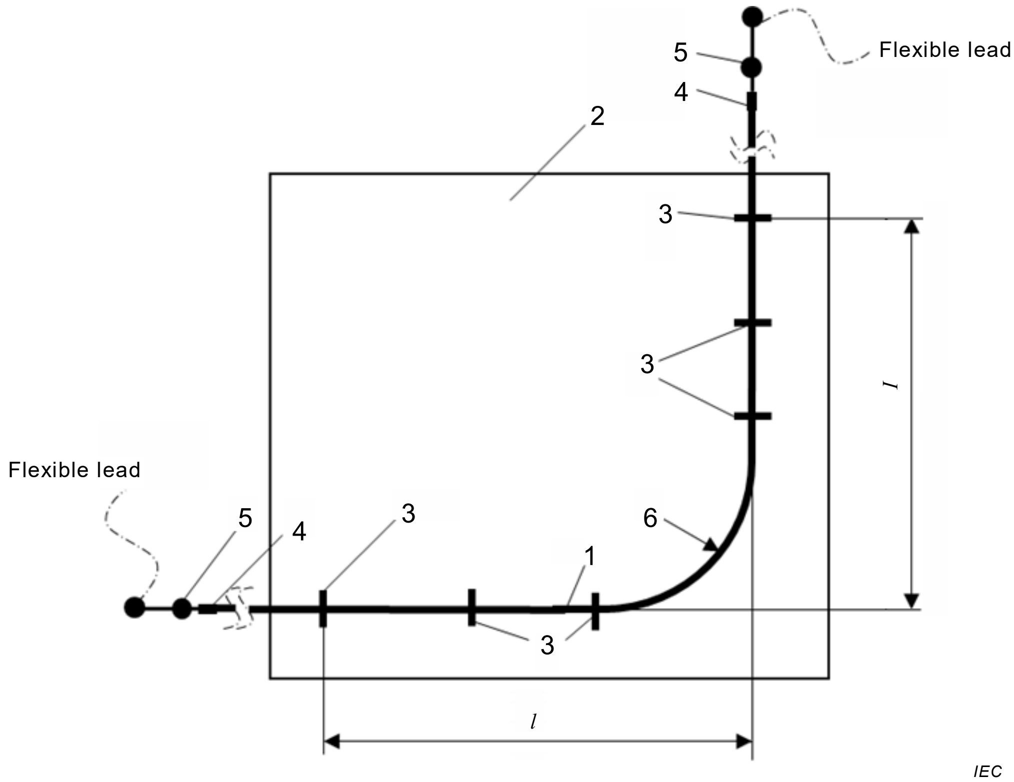
5.5.7.1 Lightning current carrying capability test

Three specimens of insulating down-conductors shall be bent to the minimum radius specified by the manufacturer and straightened a total of three times before the high voltage testing is performed. This is intended to simulate a mechanical stress which could occur during installation.

These three specimens shall be assembled as shown in Figure 13 according to the manufacturer's installation instructions, e.g. with the recommended connectors at their tightening torques.

The corrosion test specified in 5.5.5.1 shall be performed as preconditioning. The electrical test shall be performed using the test arrangement shown in Figure 13. The length l should be equal to or greater than three times the minimum bending radius of the insulating down-conductor specified by the manufacturer.

NOTE The specimen tested under these conditions is also used in the test according to 5.5.7.2. Therefore remember to use a specimen with a total length sufficient to fulfil the requirements in 5.5.7.2.2.



Key

1 insulating down-conductor

2 plate made of insulating material

3 rigid fastener

4 cable termination

5 cable termination connector

6 minimum bending radius of insulating down-conductor

l length of cable equal to or greater than three times the minimum bending radius

Figure 13 – Basic arrangement for the lightning current carrying capability test

The specimen shall be tested according to 6.4 of IEC 62561-1:2017 using the impulse current specified in Table 2 of 5.2 for the classification of insulating down-conductor specified by the manufacturer.

Pass criteria:

The change of the resistance of the test arrangement according to Figure 13, measured with a source of at least 10 A as close as possible to the connection components, is equal to or less than 3 mΩ.

In addition, the pass criteria specified in items b), c), d) and e) of IEC 62561-1:2017, 6.4 shall apply for the connectors. There shall be no sign of damage or cracks visible to normal or corrected vision for the length of the insulating down-conductor.

Pass criteria e) of IEC 62561-1:2017, 6.4 can be checked after the high voltage impulse tests 5.5.7.2.

5.5.7.2 High voltage impulse test for insulating down-conductors

5.5.7.2.1 Test setup

The electrical test is performed using the test arrangement given in Figure 14. For testing the equivalent separation distance of an insulating down-conductor, a comparison arrangement is used. The comparison arrangement uses a spark gap formed by two crossed rods above a conductive ground plane 2 m × 2 m. These rods shall have a diameter of (8 ± 0,5) mm and a length of at least 2 m. The minimum height of the grounded rod above the ground plane shall be 1,5 m. The distance between the specimen under test and the comparison arrangement shall be at least 2 m.

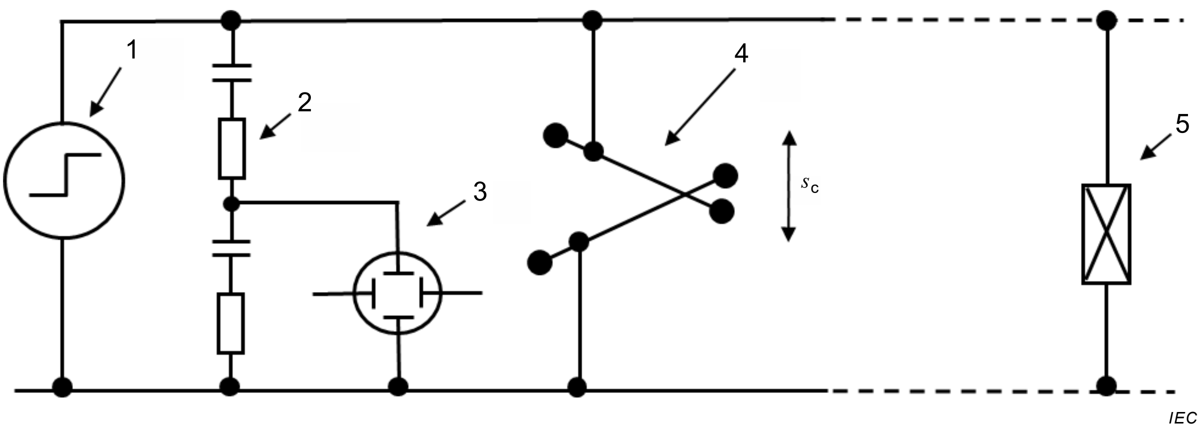
The clearance s_c of the spark gap in the comparison arrangement is used as the distance measurement for the specified equivalent separation distance under test. The test shall be performed with negative polarity only. The clearance of the comparison arrangement shall be adjusted depending on the specified equivalent separation distance s_e to a distance of:

$$s_c = \frac{s_e}{c_{dc\_st}}$$

NOTE 1 The factor c_{dc_st} is defined as the effect of higher steepness and the probability of the occurrence of subsequent negative short strokes on the equivalent separation distance of the insulating down-conductors compared to the test impulse. For a standard high voltage impulse (1,2/50 µs or faster) chopped at a time to chopping T_c = 1,2 µs the steepness correction factor c_{dc_st} can be assumed to be 1,2 for dry insulating down-conductors.

NOTE 2 Impulse generators for negative subsequent short stroke induced voltages are not readily available. Therefore Marx generators, existing in almost all high voltage laboratories, are usually used for the high voltage impulse tests. Using Marx generators a time to chopping of 1,0 µs to 1,4 µs is usually achieved. This is accepted as a test value for induced voltages expected in first negative short strokes.

For the voltage measurement, a divider according to IEC 60060-2:2010, Clause 8 and a measuring instrument according to IEC 61083-1 and IEC 61083-2 shall be used.



Key

1 high voltage impulse generator

2 high voltage impulse divider

3 impulse measuring device

4 comparison arrangement (spark gap)

5 specimen under test

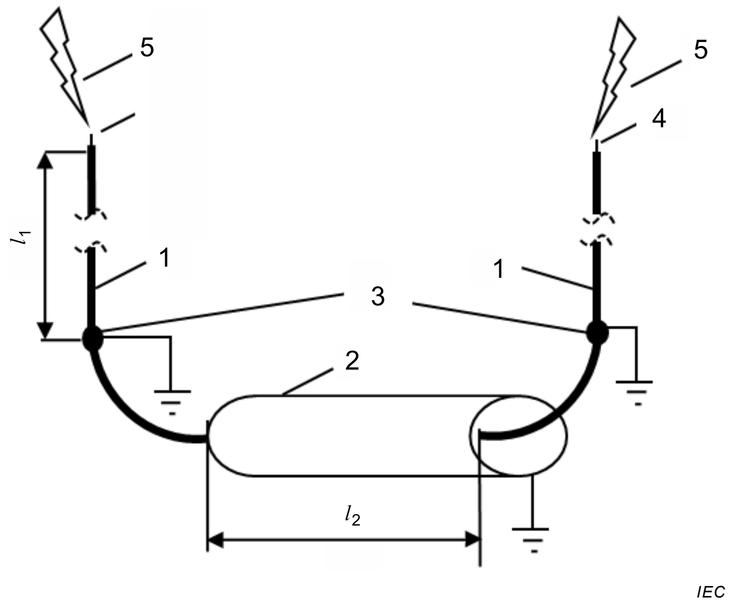
s_c gap distance of the spark gap

Figure 14 – General description of the test setup for the high voltage impulse test of the insulating down-conductor

5.5.7.2.2 Specimen preparation

Before testing the equivalent separation distance as a preconditioning the corrosion test according to 5.5.5.1 shall be performed. The specimens passing the test for 5.4.4.2 (if required) shall be used for this test.

The high voltage test arrangement for insulating down-conductors is shown in Figure 15. The metallic tube illustrated in Figure 15 should have an internal diameter not more than twice that of the cable under test. Where necessary the metallic tube may be split along its length in order to aid assembly of the test arrangement. Where the tube is split, it should be ensured that the two halves are suitably electrically connected.



Key

1 insulating down-conductor

2 metallic pipe ø ≤ 2ø cable, l_2 = 2 m

3 connection according to manufacturer installation instruction

4 inner conductor (down-conductor)

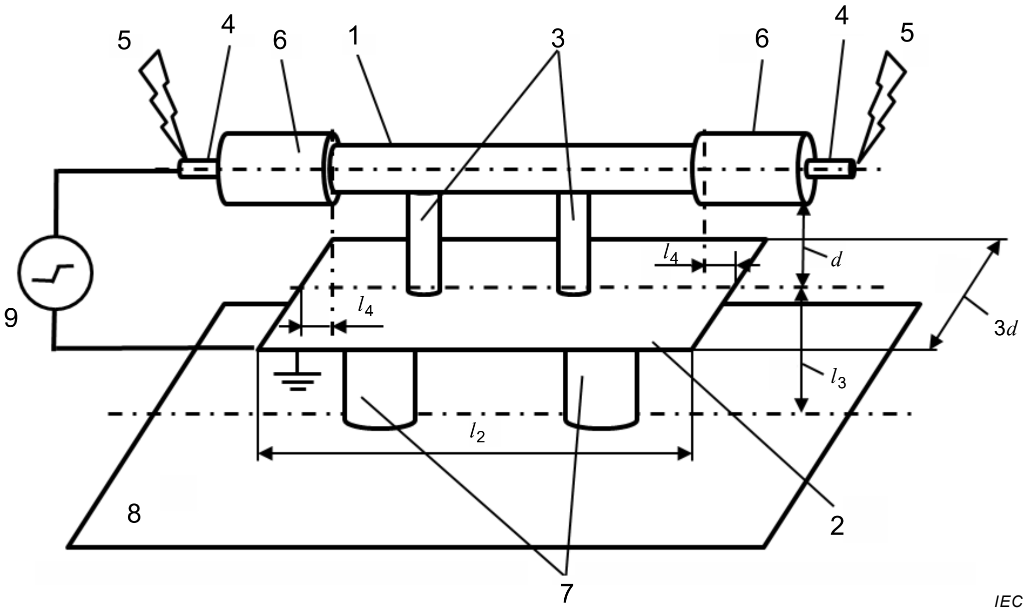
5 connection to the high voltage impulse generator

l_1 according to the manufacturer's instructions

l_2 metallic pipe length

Figure 15 – Test arrangement for insulating down-conductors

The high voltage arrangement for partially insulating down-conductors is shown in Figure 16.



Key

1 insulated down-conductor

2 metallic surface l_2 = 2 m, $l_3 > s_e$

3 support insulator according to manufacturer's instruction

4 inner conductor

5 connection to the high voltage impulse generator

6 cable termination (overlapping distance l_4 according to manufacturer's instructions)

7 support (insulating material or metal)

8 floating or grounded plate

9 generator

d clearance distance

Figure 16 – Test arrangement for partial insulating down-conductors

The length l_2 of the grounded metallic surface (2) shall be 2 m. The width should be three times the clearance distance d. The required clearance distance d is to be defined by the manufacturer. The distance l_3, in between the ground and the grounded metallic surface (2), should be larger than the separation distance s_e.

5.5.7.2.3 Test procedure

The test is performed with impulse voltages of negative polarity only.

The clearance of the comparison arrangement shall be adjusted to s_c as described above.

The impulse generator shall be initially set without a specimen connected to a peak value approximately $U_t = s_e \times 10$ kV/cm and increased incrementally until time to chopping T_c reaches the test condition of 1,0 µs < T_c < 1,4 µs.

NOTE 1 Since the specimen under test is an additional load for the generator, a fitting procedure is to adjust the generator without the specimen under test close to 1,0 µs. There is no need to verify the time to half-value of the impulse. If the condition 1,0 µs < T_c < 1,4 µs cannot be met, the damping resistors of the Marx generator are reduced in order to increase the steepness and the amplitude of the applied voltage. After U_t has been adjusted, the test specimen is connected to the impulse generator as shown in Figure 14. The test specimen is then tested with three impulses of U_t and T_c. All three impulses are recorded.

Pass criteria:

The specimen has passed the test if all three impulses cause a flashover on the comparison arrangement and the test condition 1,0 μs < T_c < 1,4 μs is fulfilled for all three tests.

If the test condition for T_c is not fulfilled, the test may be repeated with an impulse voltage increased by 5 % until the test condition for T_c is fulfilled.

The flashover can be identified using a still camera and a record from the oscilloscope. The specified separation distance s_e is confirmed by this test.

NOTE 2 In case there is doubt about the location of a flashover, a current measurement in the branch of the insulating down-conductor earthing wire can resolve the problem.

5.5.7.3 Installation arrangement test for insulating down-conductors

Supporting structures are part of an installation arrangement as defined in 3.14 in order to support one or more insulating down-conductors mechanically. Supporting structures have an influence on the dielectric strength of the installation arrangement. Compliance of the equivalent separation distance should be checked by the installation arrangement test specified in Annex F.

5.6 Electromagnetic compatibility (EMC)

Products covered by this document are, in normal use, passive with respect to electromagnetic influences (emission and immunity).

5.7 Structure and content of the test report

5.7.1 General

The purpose of this instruction is to provide general requirements for laboratory test reports. This document is intended to promote clear, complete reporting procedures for laboratories submitting test reports.

The results of each test carried out by the laboratory shall be reported accurately, clearly, unambiguously and objectively, in accordance with any instructions in the test methods. The results shall be reported in a test report and shall include all the information necessary for the interpretation of the test results and all information required by the method used.

Particular care and attention shall be paid to the arrangement of the report, especially with regard to presentation of the test data and ease of assimilation by the reader. The format shall be carefully and specifically designed for each type of test carried out, but the headings shall be standardized as indicated herein.

The structure of each report shall include at least information according to 5.7.2 to 5.7.9.

5.7.2 Report identification

a) A title or subject of the report.

b) Name, address and telephone number of the designated test laboratory. Name, address and telephone number of any sub testing laboratories where tests were carried out, if different from the designated test laboratory company which has been assigned to perform the testing. Unique identification number (or serial number) of the test report.

c) Name and address of the vendor.

d) Report shall be paginated and the total number of pages indicated on each page including appendices or annexes.

e) Date of issue of the report.

f) Date(s) of performance of test(s).

g) Signature and title, or equivalent identification of the person(s) authorized to sign for the designated testing laboratory responsible for the content of the report.

h) Signature and title of person(s) conducting the test(s).

i) Declaration to avoid misuse.

The following declaration shall be included in the test report in order to avoid misuse.

"This type test report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory. This type test report covers only the specimens submitted for test and does not provide evidence of the quality for a similar series of items or products."

5.7.3 Specimen description

a) Specimen description.

b) Functional parts and accessories description (e.g. screws, nuts, washers, quantity, material, etc.).

c) Manufacturing method – insulating conductors.

d) Detailed description and unambiguous identification of the test specimen and/or test assembly.

5.7.4 Characterization and condition of the test specimen and/or test assembly

For comparison of test results with those taken from other laboratories, it is vital to have a detailed description of materials' properties and materials' testing arrangements.

5.7.5 Insulating down-conductor

a) Conductor material.

b) Nominal cross-section area, dimensions and shape. The actual cross-sectional area should also be given.

c) Insulating material.

d) Materials for conductor fasteners and connectors.

5.7.6 Standards and references

a) Identification of the test standard (Technical Specification) used and the date of issue of the standard (Technical Specification).

b) Reference to this document may be made only if the full set of tests is performed and reported except where the deviations are clearly justified.

c) Other relevant documentation with the documentation date.

d) Test procedure.

e) Description of the test procedure.

f) Justification for any deviations from, additions to or exclusions from the referenced standard (Technical Specification).

g) Any other information relevant to a specific test such as environmental conditions.

h) Configuration of testing assembly.

i) Location of the arrangement in the testing area and measuring techniques.

5.7.7 Testing equipment, description

Description of equipment used for every test conducted, i.e. generator, conditioning/ageing device.

5.7.8 Measuring instruments description

a) Characteristics and calibration date of all instruments used for measuring the values specified in the Technical Specification, i.e. shunts, oscilloscope, ohmmeter, torque meter.

b) The dynamic behaviour for the high voltage divider used shall be fully documented. The parameters of the response according to IEC 60060-2:2010, Annex C, shall be fully documented.

5.7.9 Results and parameters recorded

a) The required passing criteria for each test, defined by the Technical Specification.

b) The relevant observed or derived results of the tests.

c) All results shall be presented by tables, graphs, oscillograms, drawings, photographs or other documentation of visual observations as appropriate.

d) A statement of pass/fail identifying the part of the test for which the specimen has failed and also a description of the failure.

e) Environmental conditions before and after the test.

Annex A
(normative)

Environmental test – corrosion resistance

A.1 General

The test consists of a salt mist test according to A.2 followed by a humid sulphurous atmosphere test according to A.3. An additional ammonia atmosphere test shall be performed, according to A.4, for specimens made of copper alloy with a copper content less than 80 %.

A.2 Salt mist test

Salt mist treatment according to IEC 60068-2-52:2017 except for Clauses 7, 10 and 11 which are not applicable.

The test is carried out using test method 2 in IEC 60068-2-52:2017, 9.4.3.

If the salt mist chamber can maintain the temperature conditions as specified in 9.3 of IEC 60068-2-52:2017 and a relative humidity of not less than 90 % then the specimen may remain in it for the humidity storage period.

A.3 Humid sulphurous atmosphere test

Humid sulphurous atmosphere treatment according to ISO 6988:1985 with seven cycles with a concentration of sulphur dioxide of (667 ± 25) ppm (in volume) except for Clauses 9 and 10 which are not applicable.

Each cycle, which has duration of 24 h, is composed of a heating period of 8 h at a temperature of 40 °C ± 3 °C in the humid saturated atmosphere, followed by a rest period of 16 h. After that, the humid sulphurous atmosphere is replaced.

If the test chamber maintains the temperature conditions as specified in 6.5.2 of ISO 6988:1985 then the specimen may remain in it for the rest period.

A.4 Ammonia atmosphere test

Ammonia atmosphere treatment according to ISO 6957:1988 for a moderate atmosphere with the pH value 10 except for Clauses 8.4 and 9 which are not applicable.

Annex B
(normative)

Environmental test – resistance to ultraviolet light

B.1 General

A set of specimens shall be subjected to ultraviolet light conditioning according to B.2, B.3 or B.4. All sets tested are considered representative of the material's entire colour range.

Specimens shall be mounted on the inside of the cylinder in the ultraviolet light apparatus so that the specimens do not touch each other and shall be positioned in such a way that the fixation surface for the rod is perpendicular to the light source.

B.2 The test

The specimens shall be exposed for (1 000 ± 1) h to a xenon-arc, method A, in accordance with ISO 4892-2. Continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of (120 ± 2) min consisting of a (102 ± 2) min light exposure and an (18 ± 1) min exposure to water spray with light, shall be used. The apparatus shall operate with a water-cooled xenon-arc lamp, borosilicate glass inner and outer optical filters, a spectral irradiance of 0,35 $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm and a black panel temperature of (65 ± 3) °C. The temperature of the chamber shall be (45 ± 5) °C. The relative humidity in the chamber shall be (50 ± 5) %.

B.3 First alternative test to B.2

The specimens shall be exposed for (720 ± 1) h to open-flame sunshine carbon-arc, in accordance with ISO 4892-4. Continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of (120 ± 2) min consisting of a (102 ± 2) min light exposure and an 18 min exposure to water spray with light, shall be used. The apparatus shall operate with an open-flame sunshine carbon-arc lamp, borosilicate glass type 1 inner and outer optical filters, a spectral irradiance of 0,35 $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm and a black panel temperature of (63 ± 3) °C. The temperature of the chamber shall be (45 ± 5) °C with a relative humidity of (50 ± 5) %.

B.4 Second alternative test to B.2

The specimens shall be exposed for total irradiation energy equal to the values given in B.2, to fluorescent UV light in accordance with ISO 4892-3. The exposure conditions shall be by continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of (300 ± 1) min light exposure and (60 ± 1) min exposure to water spray with light as described in Table 4, method A, cycle 3 of ISO 4892-3:2016.

Pass criteria:

After the test there shall be no sign of disintegration nor shall there be any crack visible to normal or corrected vision.

Annex C
(normative)

Flow chart of tests for insulating stand-offs

Figure C.1 shows a flow chart of tests for insulating stand-offs.

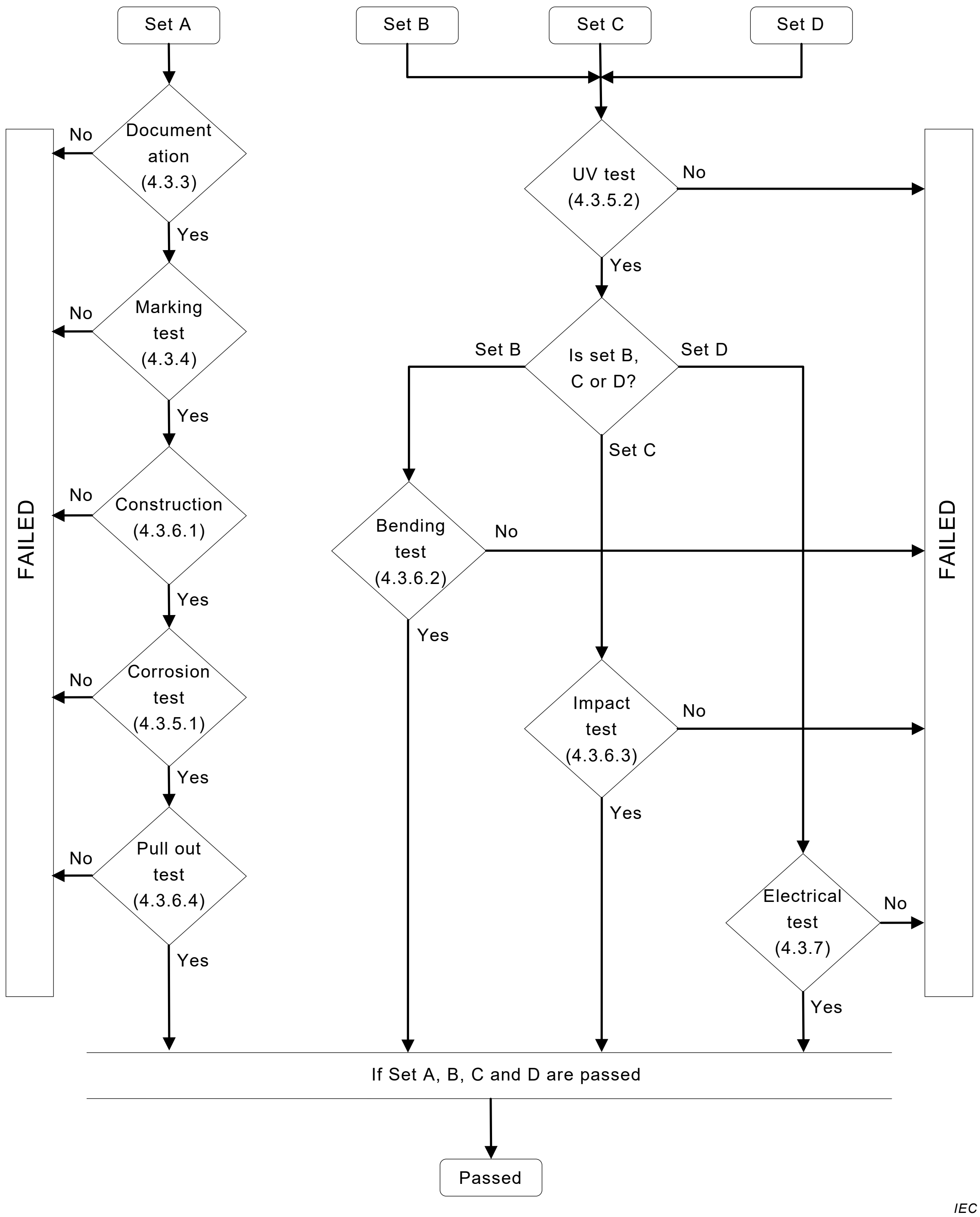


Figure C.1 – Tests for insulating stand-offs

Annex D
(normative)

Flow chart of tests for insulating down-conductors

Figure D.1 shows a flow chart of tests for insulating down-conductors.

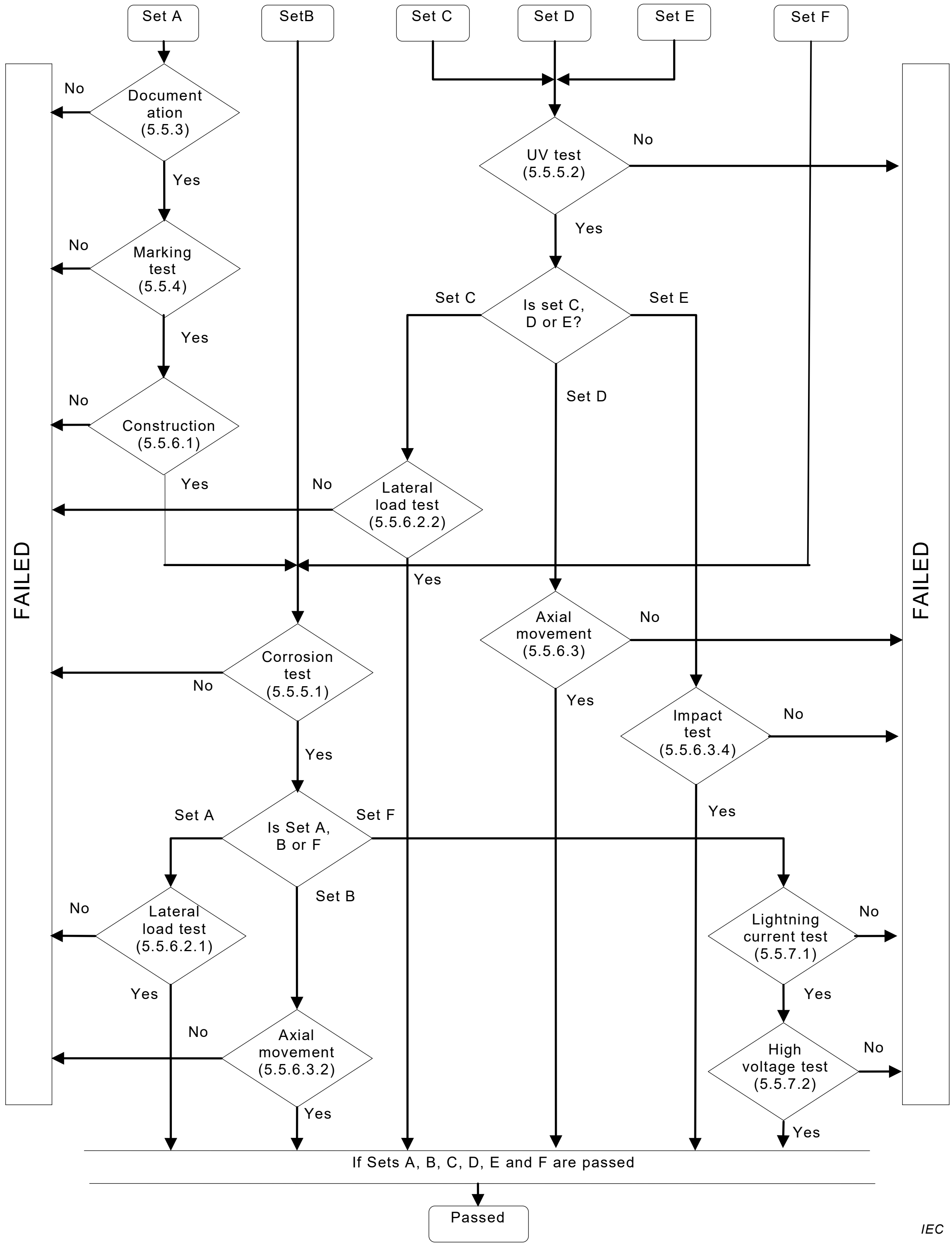


Figure D.1 – Tests for insulating down-conductors

Annex E
(informative)

High voltage impulse test to determine the actual correction factor k_x for insulating stand-offs

E.1 Specimen preparation

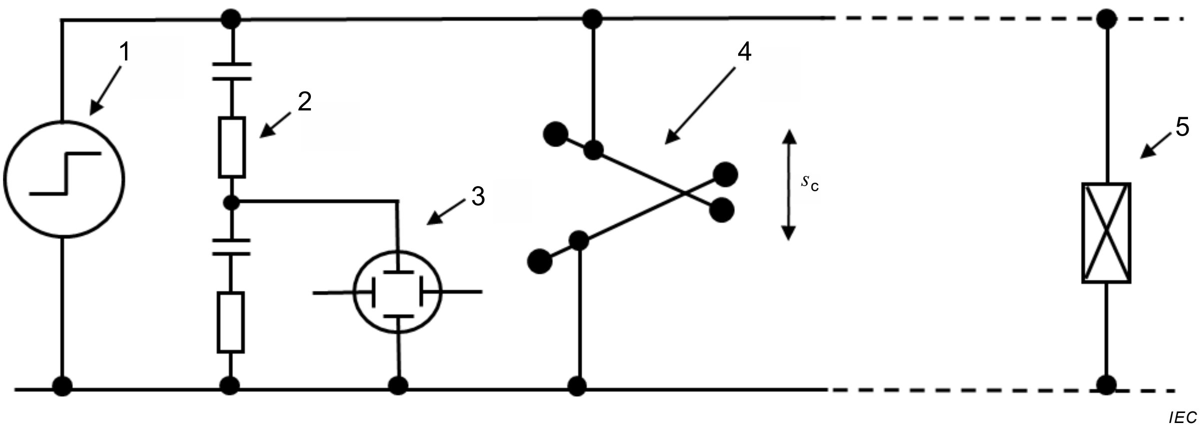
The UV light test specified in 4.3.5.2 should be performed prior to the high voltage impulse test.

One set of three specimens of the insulating stand-off with an insulating length l_{st} of (500 ± 5) mm should be assembled according to the manufacturer's installation instructions.

E.2 Test setup

The electrical test is performed using the test arrangement given in Figure E.1. For testing the equivalent separation distance of an insulating stand-off, a comparison arrangement is used. The comparison arrangement uses a spark gap formed by two crossed rods above a conductive ground plane measuring 2 m × 2 m. These rods shall have a diameter of (8 ± 0,5) mm and a length of at least 2 m. The minimum height of the grounded rod above ground plane shall be 1,5 m. The distance between the specimen under test and the comparison arrangement shall be at least 2 m.

The clearance of the comparison arrangement shall be adjusted to s_c = (300 ± 1) mm.



Key

1 high voltage impulse generator

2 high voltage impulse divider

3 impulse measuring device

4 comparison arrangement (spark gap)

5 specimen under test

s_c gap distance of the spark gap

Figure E.1 – General description of the test arrangement to determine the actual correction factor k_x for insulating stand-offs

E.3 Test procedure

The test is performed with impulse voltages of negative polarity only.

For the voltage measurement, a divider according to IEC 60060-2:2010, Clause 8 and a measuring instrument according to IEC 61083-1 and IEC 61083-2 shall be used.

Before testing, the impulse generator shall be adjusted without a specimen under test connected. The clearance of the comparison arrangement should be adjusted to s_c as noted above.

The impulse generator should be initially set without a specimen connected to a peak value of approximately U_t = 500 kV and increased incrementally until the time to chopping T_c reaches the test condition of 1,0 µs < T_c < 1,4 µs. This peak value of the applied voltage shall be recorded as $U_{t,test}$.

NOTE 1 Since the specimen under test is an additional load for the generator the correct procedure is to adjust the generator, without the specimen under test, close to 1,0 µs. There is no need to verify the time to half-value of the impulse. If the condition 1,0 µs < T_c < 1,4 µs is not met, the damping resistors of the Marx generator are reduced in order to increase the steepness and the amplitude of the applied voltage.

After $U_{t,test}$ has been evaluated, the test specimen should be connected to the impulse generator as shown in Figure E.1. The test specimen should be tested with three impulses of $U_{t,test}$. T_c should be recorded for all three impulses and fulfil the test condition 1,0 µs < T_c < 1,4 µs for all three tests.

In order to reduce the number of flashovers on the surface of the insulator, it is recommended to start with flashovers on the comparison arrangement and increase its gap distance stepwise until only three flashovers occur on the specimen.

The k_x coefficient can then be found by:

$$k_x = c_{is\_st} \times s_c \text{ [mm] / 500 [mm]}$$

where s_c is the gap distance of the comparison arrangement.

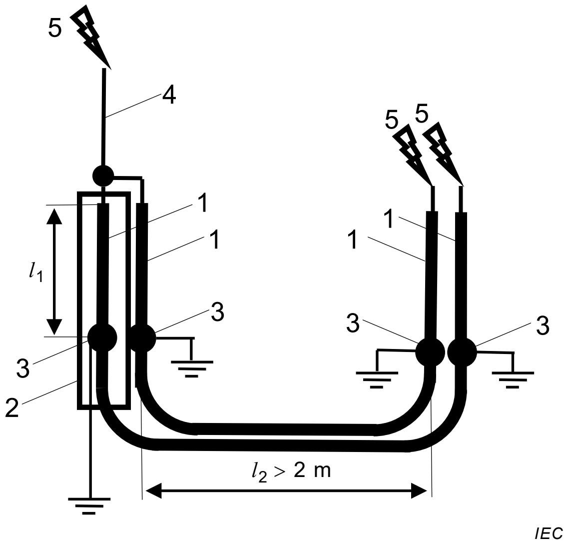
NOTE 2: The factor c_{is_st} is defined as the effect of higher steepness and the probability of the occurrence of subsequent negative short strokes on the withstand voltage of insulating stand-offs compared to the test impulse. For a standard high voltage impulse (1,2/50 µs or faster) chopped at a time to chopping T_c = 1,2 µs, the steepness correction factor c_{is_st} can be assumed to be 0,97 for a dry insulating stand-off.

Annex F
(informative)

Installation arrangement test to determine the influence of supporting structures on the separation distance

F.1 Specimen preparation for the high voltage installation arrangement test

A single set of specimen shall be arranged according to the installation instructions. New factory specimens can be used for the installation arrangement test. An example of the high voltage test setup for the installation arrangement test is given in Figure F.1.



Key

1 insulating down-conductors

2 supporting tube (e.g. GFRP)

3 connection according to installation instruction

4 air termination

5 connection to the high voltage impulse generator

l_1 according to installation instructions

l_2 distance between the two terminals

Figure F.1 – Example for installation arrangement test – specimen under test

F.2 Test procedure

Perform the high voltage impulse test according to 5.5.7.2.

NOTE 1 The installation arrangement test can be done without the metallic pipe or metallic surface as described in Figures 15 and 16.

Pass criteria:

The specimen has passed the test if all three impulses cause a flashover on the comparison arrangement and the test condition 1,0 μs < T_c < 1,4 μs is fulfilled for all three tests.

If the test condition for T_c is not fulfilled, the test may be repeated with an impulse voltage increased by 5 % until the test condition for T_c is fulfilled.

The flashover can be identified using a still camera and a record from the oscilloscope. The specified separation distance s_e is confirmed by this test.

NOTE 2 In case there is doubt about the location of a flashover, a current measurement in the branch of the insulating down-conductor earthing wire can resolve the problem.

Bibliography

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

IEC 60332-3 (all parts), *Tests on electric cables under fire conditions*

IEC 61034 (all parts), *Measurement of smoke density of cables burning under defined conditions*

IEC 62305-1:2010, *Protection against lightning – Part 1: General principles*

(Continued from second cover)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61083-2 : 2013 Instruments and software used for measurement in high-voltage and high-current tests — Part 2: Requirements for software for tests with impulse voltages and currents	IS 15638 (Part 2) : 2018 Instruments and software used for measurement in high-voltage and high current tests: Part 2 Requirements for software for tests with impulse voltages and currents (*first revision*)	Identical
IEC 62305-3 Protection against lightning — Part 3: Physical damage to structures and life hazard	IS/IEC 62305-3 : 2010 Protection against lightning: Part 3 Physical damage to structures and life hazard	Identical
ISO 6957 : 1988 Copper alloys — Ammonia test for stress corrosion resistance	IS 16872 : 2019 Copper Alloys — Ammonia test for stress corrosion resistance	Identical

The Committee has reviewed the provisions of the following international standards referred in this adopted standard and decided that they are acceptable for use in conjunction with this standard.

International Standard	*Title*
IEC 60068-2-52 : 2017	Environmental testing — Part 2: Tests–test Kb: salt mist, cyclic (sodium chloride solution)
IEC 62561-1 : 2017	Lightning protection system components (LPSC) — Part 1: Requirements for connection components
IEC 62561-2 : 2012	Lightning protection system components (LPSC) — Part 2: Requirements for conductors and earth electrodes
IEC 62561-4	Lightning protection system components (LPSC) — Part 4: Requirements for conductor fasteners
ISO 4892-2	Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps
ISO 4892-3: 2016	Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps
ISO 4892-4	Plastics — Methods of exposure to laboratory light sources — Part 4: Open-flame carbon-arc lamps
ISO 6988 : 1985	Metallic and other non-organic coatings — Sulfur dioxide test with general condensation of moisture

Only the English language text has been retained while adopting it in this Indian Standard, and as such, the page number given here are not the same as in the IEC publication.

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, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. 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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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: ETD 20 (24505).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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