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Edition 3.0 2013-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems

Essais sous pollution artificielle des isolateurs haute tension en céramique et en verre destinés aux réseaux à courant alternatif

IEC 60507:2013

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ARTIFICIAL POLLUTION TESTS ON HIGH-VOLTAGE CERAMIC AND GLASS INSULATORS TO BE USED ON A.C. SYSTEMS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60507 has been prepared by IEC technical committee 36: Insulators.

This third edition cancels and replaces the second edition published in 1991. This third edition constitutes a technical revision.

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

a) Corrections and the addition of explanatory material;
b) The addition of Clause 4.3.2 on atmospheric correction;
c) The change of the upper limit of conductivity of water to 0.1 S/m; and
d) The extension to UHV voltages.

The text of this standard is based on the following documents:

FDIS	Report on voting
36/337/FDIS	36/342/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of August 2018 have been included in this copy.

ARTIFICIAL POLLUTION TESTS ON HIGH-VOLTAGE CERAMIC AND GLASS INSULATORS TO BE USED ON A.C. SYSTEMS

1 Scope

This International Standard is applicable for the determination of the power frequency withstand characteristics of ceramic and glass insulators to be used outdoors and exposed to polluted atmospheres, on a.c. systems with the highest voltage of the system greater than 1 000 V.

These tests are not directly applicable to polymeric insulators, to greased insulators or to special types of insulators (insulators with semiconducting glaze or covered with any organic insulating material).

The object of this International Standard is to prescribe procedures for artificial pollution tests applicable to insulators for overhead lines, substations and traction lines and to bushings

It may also be applied to hollow insulators with suitable precautions to avoid internal flashover. In applying these procedures to apparatus incorporating hollow insulators, the relevant technical committees should consider their effect on any internal equipment and the special precautions which may be necessary.

2 Normative references

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

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC/TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC/TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

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

3 Terms and definitions

For the purpose of this standard, the following terms and definitions apply.

3.1
test voltage
the r.m.s. value of the voltage with which the insulator is continuously energized throughout the test

3.2
short-circuit current (I_{sc}) of the testing plant
the r.m.s. value of the current delivered by the testing plant when the test object is short-circuited at the test voltage

3.3
unified specific creepage distance
USCD
the creepage distance of an insulator divided by the maximum operating voltage across the insulator (for a.c. systems usually $U_m/\sqrt{3}$)

Note 1 to entry: This is generally expressed in mm/kV.

Note 2 to entry: This definition differs from that of Specific Creepage Distance where the phase-to-phase value of the highest voltage for the equipment is used. For phase-to-earth insulation, this definition will result in a value that is √3 times that given by the definition of Specific Creepage Distance in IEC/TS 60815 (1986). See Annex J of IEC 60815-1:2008 for details.

3.4
form factor of an insulator
Ff
dimensionless number that presents the length (l) of the partial creepage distance divided by the integrated width (p)

Note 1 to entry: For insulators, the length is in the direction of the creepage distance and the width is the circumference of the insulator.

Note 2 to entry: The form factor is calculated by the formula

$$Ff = \int_0^L \frac{dl}{p(l)}$$

where

L is the total creepage distance

$p(l)$ $= 2\pi . r(l)$

For graphical estimation of the form factor, the reciprocal value of the insulator circumference ($\frac{1}{p}$) is plotted versus the partial creepage distance l counted from the end of the insulator up to the point reckoned. The form factor is given by the area under this curve.

3.5
salinity
S_a
concentration of the solution of salt in tap water, expressed by the amount of salt divided by the volume of solution

Note 1 to entry: This is generally expressed in kg/m^3.

3.6
pollution layer
a conducting electrolytic layer on the insulator surface, composed of salt plus inert materials

Note 1 to entry: The conductance of the pollution layer on the insulator is measured in accordance with 6.5.1.

3.7
layer conductivity (*K*)
the conductance of the pollution layer multiplied by the form factor

Note 1 to entry: This is generally expressed in µS.

3.8
salt deposit density
SDD
amount of sodium chloride in an artificial deposit on a given surface of the insulator (metal parts and assembling materials are not to be included in this surface) divided by the area of this surface

Note 1 to entry: This is generally expressed in mg/cm^2.

3.9
degree of pollution
the value of the quantity (salinity, layer conductivity, salt deposit density) which characterizes the artificial pollution applied to the tested insulator

3.10
reference salinity
the value of the salinity used to characterize a test

3.11
reference layer conductivity
the value of the layer conductivity used to characterize a test

Note 1 to entry: This is defined as the maximum value of the conductivity of the wetted layer of an insulator energized only for performing the conductance measurements.

3.12
reference salt deposit density
the value of the salt deposit density used to characterize a test

Note 1 to entry: This is defined as the average of the salt deposit density values measured on a few insulators (or on parts of them), which are chosen for this purpose from among the contaminated ones prior to their submission to any test.

3.13
specified withstand degree of pollution
the reference degree of pollution at which an insulator shall withstand the specified test voltage in at least three tests out of four, under the conditions described in the relevant Clauses 5.6 or 6.8

3.14
maximum withstand degree of pollution
the highest degree of pollution at which at least three withstand tests out of four can be obtained at the specified test voltage, under the conditions described in the relevant clauses 5.6 or 6.8.

3.15
specified withstand voltage
the test voltage at which an insulator shall withstand the specified degree of pollution in at least three tests out of four, under the conditions described in the relevant 5.6 or 6.8

3.16
maximum withstand voltage
the highest test voltage at which at least three withstand tests out of four can be obtained at the specified degree of pollution, under the conditions described in the relevant 5.6 or 6.8

3.17
non-soluble deposit density
NSDD
amount of non-soluble residue removed from a given surface of the insulator, divided by the area of this surface

Note 1 to entry: This is generally expressed in mg/cm^2.

4 General test requirements

4.1 General

Pollution tests can be carried out for two main objectives:

- to obtain information about the pollution performance of insulators e.g. for comparison of different insulator types/profile
- to check the performance in a configuration as close as possible to the in-service one.

To reach the first objective, tests on relatively short insulator sets – if representative of the full set in terms of radial geometry and profile – may be sufficient. Results of such tests on insulators with an arcing length higher than 1 m can be linearly extrapolated up to and including the UHV range, at least for pollution ranging from medium to very heavy.

Tests to reach the second objective may be agreed between the manufacturer and the user whenever optimisation of the design is necessary and/or whenever it is expected that the mounting condition or the inner active parts in apparatus can affect the performance. Such tests shall be made simulating the relevant service conditions as closely as possible. In particular tests in other positions from the vertical (inclined, horizontal) duplicating actual service conditions may be agreed between the supplier and the user.

Tests at higher system voltages (800 kV and above) may present particular requirements as reported in Annex E.

4.2 Test method

The two following categories of pollution test methods are recommended for standard tests:

– the salt fog method (Clause 5) in which the insulator is subjected to a defined ambient pollution;

– the solid layer method (Clause 6) in which a fairly uniform layer of a defined solid pollution is deposited on the insulator surface;

NOTE 1 In these test methods the voltage is held constant for a period of at least several minutes. Variants in which the voltage is raised continuously to flashover are not standardized but may be used for special purposes.

NOTE 2 In testing of full scale insulators for system voltages above 800 kV, the solid layer method may be the preferred choice because of lack of experiences and possible difficulties for the salt fog method. More information on the solid layer method for such insulators is given in Annex E.

4.3 Arrangement of insulator for test

4.3.1 Test configuration

The insulator shall be erected in the test chamber, complete with the metal fittings which are invariably associated with it. The vertical position is in general suggested for comparison of different insulator types. Tests in other positions (inclined, horizontal) duplicating actual service conditions may be carried out when agreed between the manufacturer and the user. When there are special reasons not to test insulators in the vertical position (e.g. wall bushings and circuit-breaker longitudinal insulation), only the service position shall be considered.

The minimum clearances between any part of the insulator and any earthed object other than the structure which supports the insulator and the columns of the nozzles, when used, shall be not less than 0,5 m per 100 kV of the test voltage and in any case not less than 1,5 m.

The configurations of the supporting structure and the energized metal parts, at least within their minimum clearance from the insulator, shall reproduce those expected in service.

As regards the influence of capacitive effects on the test results, the following considerations can be drawn from the available experience:

– fittings are deemed not to affect the results significantly, at least for test voltages up to 450 kV;
– internal high capacitance can have some effect on the external surface behaviour, particularly in tests with solid layer methods at low pollution severity values.

4.3.2 Cleaning of insulator

The insulator shall be carefully cleaned so that all traces of dirt and grease are removed. After cleaning, the insulating parts of the insulator shall not be touched by hand.

The surface of the insulator is deemed to be sufficiently clean and free from any grease if large continuous wet areas are observed after rinsing.

In the case of the solid-layer method, before the first contamination, scrubbing with a slurry of water and inert material such as kaolin shall be done, after which the insulator shall be thoroughly rinsed with tap water. A detergent may be added to the slurry.

Before every subsequent contamination, the insulator shall again be thoroughly washed with tap water only. Hand wiping might be necessary, if either the *SDD*-levels or the test results become inconsistent.

In the case of the salt-fog method, water, preferably heated to about 50 °C, with the addition of trisodium phosphate or other detergent, shall be used, after which the insulator shall be thoroughly rinsed with tap water. Before this final treatment, scrubbing as for the solid-layer method may be done if necessary.

NOTE 1 When the volume conductivity of tap water is higher than 0,1 S/m, the use of demineralized water is recommended.

NOTE 2 If necessary, the metal parts and the assembling materials can be painted with a salt-water resistant paint to ensure that no corrosion products wash down on to the insulating surface during a test.

4.4 Requirements for the testing plant

4.4.1 Test voltage

The frequency of the test voltage shall be between 48 Hz and 62 Hz.

In general the test voltage coincides with the highest voltage (phase to earth value) the insulator is required to withstand under normal operating conditions. For equipment, it is equal to $U_m/\sqrt{3}$, U_m being the highest voltage for equipment (see IEC 60071-1). It is higher than this value when testing insulators for phase to phase configurations or for isolated neutral systems.

4.4.2 Atmospheric corrections

No humidity correction factor shall be applied. Test voltages shall be corrected for air density according to IEC 60060-1. The coefficient m is however still under investigation.

NOTE 1 The temperature in the test chamber for relative air density calculation is the temperature measured at the height of the test object prior to the test.

NOTE 2 The coefficient m depends on many factors such as pollution severity and insulator characteristics. For the time being provisionally reference can be made to value m=0,5 [1].

NOTE 3 Atmospheric correction factors for polluted insulators are presently under consideration by CIGRE SC D1.

4.4.3 Minimum short-circuit current

In the artificial pollution tests, the testing plant needs a short-circuit current (I_{sc}) higher than in other types of insulator tests to ensure that the voltage drop during the test is small and has no influence on test results. This means that I_{sc} must have a minimum value which varies with the test conditions; moreover there are also requirements on other parameters of the testing plant.

The minimum value of I_{sc} ($I_{sc\ min}$) is given in Figure 1 as a function of the electrical surface stress of the insulator under test, expressed in terms of its unified specific creepage distance.

Besides the above requirement of $I_{sc\ min}$ value, the testing plant shall comply with the two following conditions:

– resistance/reactance ratio (R/X) equal to or higher than 0,1;

– capacitive current/short-circuit current ratio ($\frac{I_c}{I_{sc}}$) within the range 0,001 – 0,1.

More information on the criteria followed to assess the above requirements is given in Annex A.

When the value of I_{sc} of the testing plant, although higher than 6 A, does not comply with the limits given in Figure 1, the verification of a specified withstand characteristic of a polluted insulator (see 5.6 and 6.8) or the determination of its maximum withstand characteristic (see Annex B) can still be performed, provided that the source validity is directly ascertained by the following check.

In each individual test of this investigation, the highest leakage current pulse amplitude is recorded and its maximum value ($I_{h\ max}$) determined considering the three tests resulting in withstand, in the withstand conditions.

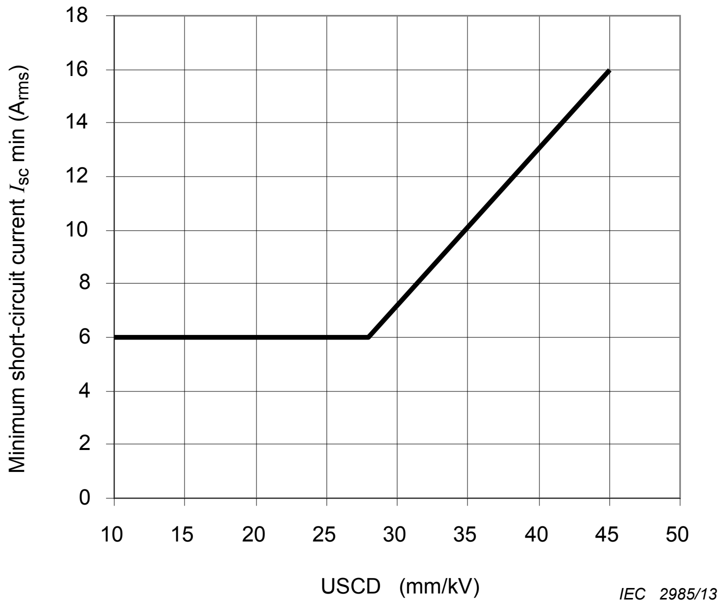
The $I_{h\ max}$ value shall comply with the expression below:

$$\frac{I_{sc}}{I_{hmax}} \geq 11$$

I_{sc} being given in r.m.s. and $I_{h\ max}$ in peak value.

More details are given in Annex A.

Since the leakage currents can be used for the interpretation of the results, it is recommended that suitable devices be arranged in order to record these currents during artificial pollution tests.



mm/kV	A_{rms}
USCD < 28	$I_{sc\ min} = 6$
28 ≤ USCD ≤ 45	$I_{sc\ min} = \lvert USCD/\sqrt{3}\rvert - 10$

Figure 1 – Minimum short-circuit current, $I_{sc\ min}$, required for the testing plant as a function of the unified specific creepage distance (USCD) of the insulator under test

NOTE The available experience is deemed insufficient to give I_{sc-min} values for tests at unified specific creepage distances higher than 45 mm/kV.

5 Salt fog method

5.1 General information

The salt fog test procedure simulates type B pollution (see IEC 60815-1) where a liquid conductive layer covers the insulator surface. In practice, this layer does not contain any significant insoluble material.

The degree of pollution in a test is defined by the salinity of the salt fog expressed in kg of salt (NaCl) per m^3 of water.

The test consists of two parts – preconditioning process (the aim of which is cleaning of the tested insulator surface) and withstand test. The detailed description of both procedures is given in 5.5 and 5.6.

NOTE The salt fog test method is not recommended for tests of insulator configurations at higher system voltage (800 kV and above). The main reason is that the specified distance between tested insulator and spraying nozzles (5.3) may be not sufficient for higher test voltages; in the frame of the recent revision with respect to the extension to the UVH range the specified distance between tested insulator and spraying nozzles was kept at 3 m in order to maintain the validity of test results with previous version of this standard.

5.2 Salt solution

The salt solution shall be made of sodium chloride (NaCl) of commercial purity and tap water.

NOTE Tap water with high hardness, for example with a content of equivalent $CaCO_3$ greater than 350 g/m^3, can cause limestone deposits on the insulator surface. In this case the use of deionized water for preparation of the salt solution is recommended. Hardness of tap water is measured in terms of content of equivalent $CaCO_3$).