

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

The European Standard EN 60507 : 1993 has the status of a
British Standard

Essais sous pollution artificielle des isolateurs
pour haute tension destinés aux réseaux à
courant alternatif

Fremdschichtprüfungen an
Hochspannungs-Isolatoren zur Anwendung in
Wechselspannungssystemen

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Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

Austria	Italy
Belgium	Luxembourg
Denmark	Netherlands
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom

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National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee and is the English language version of EN 60507 : 1993 *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*. It is identical with IEC 507 : 1991 published by the International Electrotechnical Commission (IEC).

The graphics signs, symbols and letters used may be found in the following documents.

BS 3939 *Graphical symbols for electrical power, telecommunications and electronics diagrams*

Part 1 : 1986 *General information, general index*

Part 2 : 1985 *Symbol elements, qualifying symbols and other symbols having general application*

Part 3 : 1985 *Conductors and connecting devices*

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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English version

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

(IEC 507 : 1991)

Essais sous pollution artificielle des isolateurs pour haute tension destinés aux réseaux à courant alternatif
(CEI 507 : 1991)

Fremdschichtprüfungen an Hochspannungs-Isolatoren zur Anwendung in Wechselspannungssystemen
(IEC 507 : 1991)

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

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

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 507 : 1991 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60507 on 9 December 1992.

The following dates were fixed:

- latest date of publication
of an identical national
standard (dop) 1993-12-01
- latest date of withdrawal
of conflicting national
standards (dow) 1993-12-01

For products which have complied with the relevant national standard before 1993-12-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1998-12-01.

Annexes designated 'normative' are part of the body of the standard. In this standard, annex ZA is normative.

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

SECTION ONE - GENERAL

1 Scope

This 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 ranging from 1 000 V up to 765 kV.

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

2 Object

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

3 Definitions

For the purpose of this standard, the following 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 Specific creepage distance (L_s) of an insulator

The overall creepage distance L of an insulator divided by the product of the test voltage and $\sqrt{3}$; it is generally expressed in mm/kV.

3.4 Form factor of an insulator (F)

The form factor is determined from the insulator dimensions. For graphical estimation of the form factor, the reciprocal value of the insulator circumference ($1/p$) 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 and calculated according to the formula:

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

3.5 Salinity (S_a)

The concentration of the solution of salt in tap water, expressed by the amount of salt divided by the volume of solution; it is generally expressed in kg/m³.

3.6 Pollution layer

A conducting electrolytic layer on the insulator surface, composed of salt plus inert materials.

The conductance of the pollution layer on the insulator is measured in accordance with 16.1.

3.7 Layer conductivity (K)

The conductance of the pollution layer multiplied by the form factor; it is generally expressed in μS .

3.8 Salt deposit density (SDD)

The amount of salt in the 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 (see 16.2); it is generally expressed in mg/cm².

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: it 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: It 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 11 or 19.

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 11 or 19.

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 clauses 11 or 19.

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 clauses 11 or 19.

SECTION TWO - GENERAL TEST REQUIREMENTS

4 Test methods

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

- the salt fog method (section three) in which the insulator is subjected to a defined ambient pollution;
- the solid layer method (section four) in which a fairly uniform layer of a defined solid pollution is deposited on the insulator surface.

NOTE - 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.

5 Arrangement of insulator for test

5.1 *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 purchaser. 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. The arrangement of the nozzles and their construction are described in clause 8.

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.

5.2 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.

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

Water, preferably heated to about 50 °C, with the addition of trisodium phosphate or another detergent, shall be used, after which the insulator is to be thoroughly rinsed with tap water. The surface of the insulator is deemed to be sufficiently clean and free from any grease if large continuous wet areas are observed.

Before every subsequent contamination the insulator shall be again thoroughly washed with tap water only, to remove all traces of pollution.

6 Requirements for the testing plant

6.1 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 71-1). It is higher than this value when testing insulators for phase to phase configurations or for isolated neutral systems.

6.2 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. 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 specific creepage distance L_s .

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 (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 appendix 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 clauses 11 and 18) or the determination of its maximum withstand characteristic (see appendix 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:

$$I_{sc}/I_{h \max} \geq 11$$

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

More details are given in appendix 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.

SECTION THREE - SALT FOG METHOD

7 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/m³, 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^* .

The salinity used shall have one of the following values: 2,5 - 3,5 - 5 - 7 - 10 - 14 - 20 - 28 - 40 - 56 - 80 - 112 - 160 and 224 kg/m³.

The prescribed tolerance error in salinity is ± 5 % of the specified value.

It is recommended that the salinity be determined either by measuring the conductivity or by measuring the density with a correction of temperature.

Table 1 gives the correspondence between the value of salinity, volume conductivity and density of the solution at a temperature of 20 °C.

* In accordance with the *Condensed Chemical Dictionary*, revised by G. Hawley - Encyclopedia of Chemistry; Van Nostrand Reinhold Company, New York (USA), 1971.