

Guide to

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

Committees responsible for this British Standard

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National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee using technical report IEC 1245 *Artificial pollution tests on high-voltage insulators to be used on d.c. systems*, published by the International Electrotechnical Commission (IEC). PEL/70 the British Committee responsible, recommended that this standard was published as a guide as it has many pieces of excellent information and it is anticipated that IEC will review this type 2 technical report in 1996, taking into account the comments from users of IEC 1245. In 1996 IEC will decide either to keep the technical report for a further 3 years or to convert it into an International Standard or to withdraw the publication depending upon the comments they have received from national standards bodies, such as BSI. The graphics signs, symbols and letters used may be found in the following British Standards.

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.*

Cross-references

International Standard	Corresponding British Standard
IEC 60-1:1989	BS 923 <i>Guide on high-voltage testing techniques</i> Part 1:1990 <i>General</i> (Identical)
IEC 507:1991	BS EN 60507:1993 <i>Artificial pollution tests on high-voltage insulators to be used on a.c. systems</i> (Identical)

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Introduction

The electrical strength of d.c. insulation under pollution conditions determines, in many cases, the dimensions and the design of the insulation.

For the time being, ± 600 kV is the highest voltage of the d.c. systems in use and, since laboratory experience is only available up to this system voltage level, it is chosen as the limit for this report. Higher system voltages will be considered when sufficient results are available.

For the time being it is still difficult to determine the service performance of d.c. insulators by means of the results from the artificial pollution tests proposed by this report. In particular for the highest system voltages, experience from both artificial pollution tests and service is still limited and more experience in both areas is needed for reliable service predictions. Artificial tests, therefore, give only an estimate of the performance of insulators under service conditions. These artificial pollution tests are in general short time tests compared to the expected life-time of insulators in service and, therefore, are not suitable as ageing tests.

The text of this report should be considered as an attempt to improve the reproducibility of the d.c. pollution test procedures. Further experience and additional laboratory results are still required to establish the reproducibility of the salt fog and solid layer test procedures described in this report. Therefore, it is not possible to define a confidence interval for d.c. pollution test results.

The d.c. test procedures as specified in this report follow closely the ones established for a.c. by IEC 507. This does not exclude the possibility that at a later time other d.c. test procedures will be defined. For example, uneven wetting which can occur on wall bushings in certain positions, may lead to flashovers at much lower voltages than those obtained during pollution tests with uniformly wetted surfaces. In this case simulation of the wetting and determination of the withstand voltage may be appropriate.

The main differences between this report and IEC 507 are:

- test circuit requirements include ripple factor, voltage drop and voltage overshoot. No requirements are made for the minimum short circuit current or ratio between short circuit and leakage currents;
- different criteria for the identification of flashover are given;
- for the salt fog test, a pre-conditioning process with d.c. voltage may be used by agreement;

- the wetting rate, rather than the steam injection rate, is prescribed; the measurement of the layer conductance is used to check the wetting action of the fog;

- as regards the solid layer methods, only the test procedure type “B” is considered due to the high scatter of the results obtained with tests carried out according to the type “A” procedure.

For the test methods described below, it is recommended that the voltage for the withstand voltage tests be specified as the highest value of operating voltage which occurs under normal operating conditions. Other test voltages may be agreed upon. The tests are usually carried out at negative polarity but tests with positive polarity or both may be required.

Only those test methods in which the voltage is held constant during the whole test are considered suitable for standardization. Variants in which the voltage is raised continuously to flashover are not proposed for standardization, but may be used for special purposes.

The leakage current may be used for interpretation of the test results, and therefore it is recommended that this current be continuously measured during the artificial pollution tests.

To achieve repeatable results, the artificial layer for d.c. pollution tests shall be as uniform as possible. In general non-uniform pollution distribution seems to influence d.c. withstand and flashover voltages more than in the case of a.c.

The amount of non-soluble material on the insulator surface may affect the test results. Although this matter is under consideration and no requirements can be given, the definition of non-soluble deposit density has been introduced into this report for reference.

The type of non-soluble material and its origin may also affect the test results.

The following problems need further investigation:

- effectiveness of preconditioning with d.c. voltage in the case of salt fog procedure;
- influence of non-soluble materials on the test results in the case of solid layer procedure;
- influence of steam rate and actual d.c. field on wetting characteristics.

Studies concerning d.c. pollution tests are continuing in a joint CIGRE/IEEE programme. Some information is already available in ELECTRA No. 140 in a paper published by CIGRE TF 33-04-04 entitled: "Artificial pollution testing of HVDC insulators: analysis of factors influencing performance". This paper will be supplemented when the programme is completed and the information will be used for a future revision of this report.

Section 1. General

1.1 Scope

This technical report is applicable to the determination of the withstand characteristics of ceramic and glass insulators to be used outdoors and exposed to polluted atmospheres, on d.c. systems with voltages from $\pm 1\,000\text{ V}$ up to $\pm 600\text{ kV}$.

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

This report presents procedures for artificial pollution tests applicable to d.c. overhead-line insulators, substation insulators and traction line insulators. It may also be applied to bushings with suitable precautions to avoid internal damage and to hollow insulators intended for use in other apparatus. In applying these procedures to apparatus incorporating hollow insulators, the relevant technical committees should consider their effect on the internal equipment and the special precautions which may be necessary.

NOTE For largest objects such as large wall bushings and transducers, a high spread of test results has been experienced.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this technical report. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this technical report are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60-1:1989, *High-voltage test techniques — Part 1: General definitions and test requirements*.

IEC 507:1991, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*.

1.3 Definitions

For the purpose of this technical report the following definitions apply.

1.3.1

individual test

one single process consisting in applying to the object a specified test voltage, for a specified time or until flashover occurs, at a specified degree of pollution

1.3.2

actual mean voltage (U_a)

mean value of the voltage at a given instant over a time interval ending at the instant considered and having a duration equal to that of one cycle of the alternating voltage supplying the rectifier

NOTE When it is not possible to determine the cycle of the supply voltage, the time interval is 20 ms.

1.3.3

test voltage (U_t)

actual mean voltage at the beginning of an individual test

1.3.4

ripple factor

ratio of the ripple amplitude to the actual mean voltage (U_r/U_a in Figure 1)

1.3.5

voltage drop (Δu_t)

difference between the test voltage and the actual mean voltage (Figure 2)

1.3.6

relative voltage drop

ratio of the voltage drop Δu_t to the test voltage (U_t) usually expressed as a percentage

1.3.7

voltage overshoot

difference between the actual mean voltage and the test voltage (Figure 2)

1.3.8

relative voltage overshoot

ratio of the voltage overshoot to the test voltage U_t , usually expressed as a percentage

1.3.9

leakage current

current measured in series with the insulator surface at its earth end during a pollution test

1.3.10

highest leakage current during an individual test

highest leakage current value occurring during an individual test without flashover

1.3.11**short-circuit current**

current delivered by the complete testing circuit, when the test object is energized at the test voltage and then short-circuited

1.3.12**current limiting resistor (R_s)**

resistor between the load capacitor of the d.c. supply and the test object

1.3.13**salinity (S_a)**

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/m^3

1.3.14**pollution layer**

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

1.3.15**layer conductance (G_L)**

ratio current/voltage measured as specified in Annex B

1.3.16**salt deposit density (S_D)**

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 clause 4.4); it is generally expressed in mg/cm^2

1.3.17**non-soluble deposit density (S_N)**

amount of non-soluble material 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; it is generally expressed in mg/cm^2

1.3.18**degree of pollution**

value of the quantity (salinity, salt deposit density) which characterizes the artificial pollution applied to the test insulator

1.3.19**reference salinity**

value of the salinity used to characterize an individual test

1.3.20**reference salt deposit density**

value of the salt deposit density used to characterize an individual 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

1.3.21**specified withstand degree of pollution**

reference degree of pollution at which an insulator shall withstand the specified test voltage in at least three individual tests out of four, under the conditions described in the relevant clauses 3.5 or 4.6

1.3.22**maximum withstand degree of pollution**

highest degree of pollution at which an insulator has withstood at least three individual tests out of four at the specified test voltage, under the conditions described in 5.1.1

1.3.23**specified withstand voltage**

test voltage at which an insulator shall withstand the specified degree of pollution in at least three individual tests out of four, under the conditions described in the relevant clauses 3.5 or 4.6

1.3.24**maximum withstand voltage**

highest test voltage at which an insulator has withstood at least three individual withstand tests out of four at the specified degree of pollution, under the conditions described in 5.1.2

1.3.25**50 % withstand voltage**

test voltage at which an insulator has 50 % probability to withstand one individual test (see 5.1.3)

Section 2. General test requirements**2.1 Test methods**

The pollution test methods which have been developed can be classified into two categories:

- the salt fog method (section 3) in which a clean and wet insulator is energized and then subjected to a defined ambient pollution;
- the solid layer method (section 4) in which an insulator with a dry, uniform layer of a defined solid pollution is energized and then humidified.

The following clauses in this section apply to both methods.

2.2 Arrangement of the insulator for the test

2.2.1 Test configuration

The vertical position is in general suggested for comparison of different insulator types. Tests in other positions (inclined, horizontal reproducing) 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 insulator shall be erected in the test chamber complete with any metal fittings which are an integral part of it.

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

As regards their influence on the test results, the available experience indicates that:

- external capacitances, e.g. due to fittings, do not significantly affect the results;
- the characteristics of internal components may affect the withstand value.

2.2.2 Insulator cleaning

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 or, as an alternative, Tonoko or kieselguhr 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 S_D -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 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.

2.3 Requirements for the test circuit

2.3.1 Test voltage

Throughout the test, the insulator shall be continuously energized at the specified test voltage and polarity.

No humidity correction factor shall be applied.

NOTE The application of an air density correction factor is under consideration.

The ripple factor of the test voltage demonstrated in a suitable way, shall be $\leq 3\%$ for a current of 100 mA with a resistive load.

The relative voltage drop (Figure 2) occurring during individual tests resulting in withstand shall not exceed 10 %.

NOTE Criteria for demonstrating that relative voltage drops $> 10\%$ are acceptable are under consideration. Provisionally, relative voltage drops exceeding 10 %, but not 15 %, may be tolerated, provided that the mean of the relative voltage drops evaluated during the whole of the corresponding current pulse does not exceed 5 %.

The relative voltage overshoot (Figure 2), usually due to load-release caused by extinction of electrical discharges on the insulator surface, shall not exceed 10 %.

If a flashover occurs during the time when a relative voltage overshoot is between 5 % and 10 %, the test is not valid.

2.3.2 Characteristics of the measuring systems

The systems used for measuring voltage and leakage current shall have an upper limiting frequency of at least 1 kHz.

2.3.3 Identification of flashover

The complete bridging of the insulator under test by the short-circuit arc in the case of apparent flashover shall be demonstrated. One of the following criteria is sufficient:

- the voltage recording clearly indicates a breakdown to arc-voltage;
- the current measurements indicate the short-circuit of the complete circuit by an arc;