

Insulators for overhead lines with a nominal voltage above 1 000 V — AC power arc tests on insulator sets

ICS 29.080.10

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

National foreword

This British Standard reproduces verbatim IEC 61467:1997 (Technical Report Type 2), including the Corrigendum dated May 1997 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee PEL/36, Insulators for power systems, to Subcommittee PEL/36/2, Line insulators, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, the IEC title page, pages 2 to 35 and a back cover.

Amendments issued since publication

Amd. No.	Date	Text affected

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 May 1999

© BSI 05-1999

ISBN 0 580 32484 2

**RAPPORT
TECHNIQUE
TECHNICAL
REPORT**

**CEI
IEC**

61467

Première édition
First edition
1997-02

**Isolateurs pour lignes aériennes de tension nominale
supérieure à 1 000 V –**

**Essais d'arc de puissance en courant alternatif
des chaînes d'isolateurs équipées**

**Insulators for overhead lines with a nominal voltage
above 1 000 V –**

AC power arc tests on insulator sets



Numéro de référence
Reference number
CEI/IEC 61467: 1997

CONTENTS

	Page
FOREWORD	3
 Clause	
1 Scope and object	5
2 Normative references	6
3 Definitions	6
4 Symbols and abbreviations	7
5 Test arrangement	7
6 Test current	8
7 Supply and return circuit conditions	8
8 Arc initiation	9
9 Ambient conditions	10
10 Test series and characteristics of the power arcs	10
11 Test report	11
12 Evaluation of results	11
12.1 Visual examination	11
12.2 Porcelain or glass insulators	12
12.3 Composite insulators	12
12.4 Acceptance criteria	12
 Tables	
1 Supply and return conditions	9
2 Test series	11
3 Test assessment criteria	13
 Figures	
1 Illustration of supply and return currents	14
2 Arc initiation	15
 Annexes	
A Test arrangements and practical methods of tower simulation (return circuit)	16
B Determination of the r.m.s. value of the current	21
C No-load voltage of the power source	23
D Power arcs on insulator sets and their true simulation by appropriate positioning of fusible wires	24
E Wind velocity during power arc tests	26
F Variation of the fault current magnitude and reasons for the choice of the prescribed test parameters	27
G Recommendations for the test report	29
H Sample of a power arc test report	33

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSULATORS FOR OVERHEAD LINES WITH A NOMINAL VOLTAGE ABOVE 1 000 V –

AC power arc tests on insulator sets

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of type 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 1467, which is a technical report of type 2, has been prepared by subcommittee 36B: Insulators for overhead lines, of IEC technical committee 36: Insulators.

The text of this technical report is based on the following documents:

Committee draft	Report on voting
36B/126/CDV	36B/160/RVC

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

This document is being issued as a type 2 technical report series of publications (according to G.3.2.2 of part 1 of the IEC/ISO Directives) as a "prospective standard for provisional application" in the field of power arc testing of insulator sets for overhead lines because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this technical report (type 2) will be carried out not later than three years after its publication with the options of: either extension for another three years, conversion into an International Standard, or withdrawal.

Annexes A and B form an integral part of this technical report.

Annexes C to H are for information only.

INSULATORS FOR OVERHEAD LINES WITH A NOMINAL VOLTAGE ABOVE 1 000 V –

AC power arc tests on insulator sets

1 Scope and object

This type 2 IEC technical report applies to insulator sets comprising string insulator units of ceramic material, glass or composite material for use on a.c. overhead lines and traction lines with a nominal voltage above 1 000 V and a frequency between 15 Hz and 100 Hz.

This technical report also applies to insulator sets of similar design used in substations.

This technical report establishes a standard test procedure for power arc tests on insulator sets.

This technical report does not apply to insulator sets mounted on non-metallic poles or towers.

The object of this technical report is:

- to define the terms used;
- to prescribe a standard test procedure;
- to prescribe criteria to evaluate the results of the tests.

Power arc tests are not an obligatory element of line insulator specifications. The standard test procedure and the evaluation criteria described in this report are intended to provide testing guidance when power arc tests are felt to be necessary. It is not the object of this report to introduce a general obligation to execute these tests.

As the test procedure in this technical report is intended to simulate conditions encountered in service, attention is drawn to the fact that it is not possible to extrapolate the behaviour of an insulator set of a given length to that of an insulator set of different length or equipped with fittings of different design or materials. In particular, the concept of testing a short standard string cannot be used to determine the behaviour of a complete insulator set.

The test procedure described in this technical report consists of two possible series of power arc applications at different current levels and of different duration. This test procedure is intended to cover fault current conditions occurring at representative points along a line. The test procedure is also intended to reproduce pollution-induced power arc flashover, which creates the most severe conditions.

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 editions indicated were 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 edition of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(471): 1984, *International Electrotechnical Vocabulary (IEV) – Chapter 471: Insulators*

IEC 383-1: 1993, *Insulators for overhead lines with a nominal voltage above 1 000 V – Part 1: Ceramic or glass insulator units for a.c. systems – Definitions, test methods and acceptance criteria*

IEC 383-2: 1993, *Insulators for overhead lines with a nominal voltage above 1 000 V – Part 2: Insulator strings and insulator sets for a.c. systems – Definitions, test methods and acceptance criteria*

3 Definitions

For the purposes of this technical report, the following definitions apply. Definitions of other terms used in this technical report can be found in IEC (50)471, IEC 383-1 and IEC 383-2.

3.1 test: One application of the specified test current for the specified duration to the insulator set.

3.2 test sequence: Three successive tests on the same insulator set.

3.3 test series: A group of three test sequences used to characterise the power arc performance of an insulator set.

3.4 percent initial asymmetry of current: Deviation of the current from a symmetrical wave during the first cycle of a power arc. Percent initial asymmetry is expressed as a function of the absolute peak value of the current of the first cycle divided by the r.m.s. value of the current as follows:

$$\left(\frac{|I_m|}{I \times \sqrt{2}} - 1 \right) \times 100$$

3.5 supply circuit: The electrical connection through which the current of a power arc flows to the line side of the test object from the power source.

3.6 return circuit: The electrical connection through which the current of a power arc flows from the earth side of the test object to the power source.

3.7 balanced circuit: A supply or return circuit in which the current flow is in two diametrically opposed directions.

3.8 unbalanced circuit: A supply or return circuit in which the current flow is principally in one direction.

4 Symbols and abbreviations

These symbols and abbreviations are principally used in the tables and figures hereafter.

Unless otherwise stated, currents and voltages are expressed as r.m.s values.

I	Arc current
I_n	Specified arc current
t	Arc time
t_n	Specified arc time
I_m	Peak current value
$I_{R1,2}$	Currents in the return circuit
$I_{S1,2}$	Currents in the supply circuit
I_{sys}	Rated short-circuit current of the system
L_A	Length of the insulator string
L_B	Length of the insulator set
L_R	Length of simulation of the return circuit
L_S	Length of simulation of the supply circuit
D	Distance from the centre point of the tested insulator set to the surrounding framework
M_L	Mechanical load on the tested insulator set
α	Angle from the horizontal plane of a tension insulator set
SFL	Specified minimum (electro-)mechanical failing load
SML	Specified mechanical load

5 Test arrangement

The test arrangement shall duplicate the actual configuration of the complete insulator set, and as closely as possible, that of the conductor and of the part of the tower nearest to the insulator set. The actual protective fittings shall be used and their position with respect to the insulator units, the clamps and the conductor shall be reproduced. The aim of the true simulation of the actual configuration is to recreate the real electromagnetic field affecting the arc movement.

The distances between the insulator set and the grounded structures simulating the tower shall be the same as for the service configuration. In the case of some insulator sets (such as extra high voltage, special configurations), the actual simulation of the tower may be limited by the facilities of test laboratories. In the case of long insulator sets ($L_B > 6$ m), a distance D of 6 m between tower and line conductors is sufficient.

The distance from the conductors to the ground plane shall be at least $L_B/2$ or 3 m for $L_B > 6$ m.

The test arrangement shall include a conductor or conductor bundle having characteristics similar to the one used in service. To create the real electrodynamic forces affecting the arc movement, the conductor length on both sides of the insulator sets shall be at least equal to the insulator set length but its minimum length shall be 2,5 m. In the case of long insulator sets ($L_B > 6$ m), a conductor length L_S of 6 m is sufficient (see annex A).

Some appropriate test arrangements and tower simulations (return circuit) are shown in annex A.

In order to avoid poor electrical contacts and to ensure that the insulator set is correctly positioned, a mechanical load shall be applied to the insulator set. In the case of vertical insulator sets, this load can be applied by means of a suitable weight suspended from the suspension clamp or conductor by means of an insulated link. The value of the load shall be at least 5 kN on the complete insulator set. In the case of tension insulator sets, a higher mechanical load may be necessary to reproduce the service angle of the insulator set (see figure A.4).

6 Test current

The tests shall be made with single-phase alternating current. Initial asymmetry (d.c. component) shall not exceed 30 %.

NOTE – This requirement is explained by the fact that the flashovers on a contaminated insulator set in service generally occur in the vicinity of a voltage peak, consequently with a minimal direct current component.

For 50 Hz or 60 Hz systems, the frequency of the test circuit shall be from 45 Hz to 65 Hz. For other system frequencies, the frequency of the test supply shall not in principle deviate from the specified value by more than 10 %. By agreement with the user, tests may be performed at a higher or lower frequency than the intended operating frequency. The frequencies may vary within the above limits during each test.

The test circuit shall be adequate to supply the specified values of arc current (r.m.s) and arc duration. Annex C gives information on no-load voltages suggested to achieve specified current values. Unless agreed otherwise, the permissible tolerance of the arc current with respect to the specified r.m.s. value of the current is ± 10 %.

The actual arc current during the test shall be practically sinusoidal. The r.m.s. value of the test current may be derived from the arithmetic mean of the peak values during the test duration (see annex B). If the measuring equipment permits, the r.m.s. value may be calculated from the current function.

The test current shall be essentially constant over the arcing time. During the arcing time, the following deviations from the specified value are permissible.

- The arc current crest values shall not deviate from the specified value ($I_n\sqrt{2}$) by more than ± 20 %.
- For arcing times greater than 0,2 s, the above tolerance may be exceeded during not more than 20 % of the total arcing time.

In any case the product of the actual arc current and duration $I \cdot t$ shall be within ± 10 % of the product of the specified arc current and duration $I_n \cdot t_n$.

In cases where the movement of the arc root on to the tower or along the line conductor occurs, these tolerances may be exceeded.

7 Supply and return circuit conditions

The supply and return circuits depend on the service conditions, notably on the location of the insulator set along the line and on the tower geometry. The characteristic cases to be simulated in tests are given in table 1 and illustrated in figure 1.

Table 1 – Supply and return conditions

	Balanced supply circuit	Unbalanced supply circuit
Balanced return circuit	A circuit $I_{R1} = I_n/2$ $I_{R2} = I_n/2$ $I_{S1} = I_n/2$ $I_{S2} = I_n/2$ For example: insulator set in the centre phase window of a tower in the middle of a line	B circuit $I_{R1} = I_n/2$ $I_{R2} = I_n/2$ $I_{S1} = I_n$ $I_{S2} = 0$ For example: insulator set in the centre phase window of a tower at the extremity of a line
Unbalanced return circuit	C circuit $I_{R1} = I_n$ $I_{R2} = 0$ $I_{S1} = I_n/2$ $I_{S2} = I_n/2$ For example: insulator set on the lateral phase cross-arm of a tower in the middle of a line	D circuit $I_{R1} = I_n$ $I_{R2} = 0$ $I_{S1} = I_n$ $I_{S2} = 0$ For example: insulator set on the lateral phase cross-arm of a tower at the extremity of a line

The permissible deviation of the currents I_{R1} , I_{R2} , I_{S1} and I_{S2} from their specified value shall not exceed $\pm 20\%$. This may be verified by a circuit calibration test.

8 Arc initiation

The arc shall be initiated by fusible wire of a low resistance material (for example silver, aluminium, copper) with a maximum total cross-section of 1 mm². If more than one wire is used, they shall be twisted together in parallel.

NOTE – If there are problems in initiating the arc, a larger diameter fusible wire may be used. However, it should be noted that this can have an adverse effect on the test result due to reduced initial arc mobility and deposition of metal on the insulator surface.

The aim of the specified arc initiation is to create conditions similar to that of a flashover occurring on a contaminated insulator set. This kind of flashover can cause the arc to root on intermediate points along the string. The description of the arcing phenomenon and the detailed explanation of the positioning of fusible wires are given in annex D.

The fusible wires shall be attached to the metal parts by a single point contact in the following manner and as shown in figure 2.

a) Cap and pin insulator sets

The first wire shall be attached to the cap of the earth side unit and to the pin of an intermediate unit at an interval of three to five units. The following wire is placed in the same manner, but on the opposite side of the string. This method shall be repeated up to the end of the string. Figure 2a shows the positioning of the wires and the connection of the wire to the limit point of the cap and the shed and to the pin. When there are practical difficulties to attach the fusible wire to the pin (for example due to the shape of the insulators), it is allowed to be attached to the cap of the next insulator.

In case of short insulator sets, having less than six units, one change-over point shall be created on the string approximately in the middle.

b) Long rod and composite insulator sets

The wire shall be attached between the metal parts of the insulator and be wrapped around the core in the middle of the insulator going to the opposite side. The different units shall have separate fuse wires according to figure 2b.

In the case of longer insulator sets (such as unit insulator length >1,5 m) the wire shall be attached between the metal parts of the insulator and be wrapped around the core going to the opposite side of the insulator at distances of 0,6 m to 0,8 m according to figure 2c.

In all cases (cap and pin, long rod, composite insulator sets, vertical-, Vee-, horizontal insulator sets) the plane of the fuse wires shall have an angle of 45° to the conductors (see figures 2d and 2e).

The attachment point of the fusible wire shall be moved to an adjacent quadrant for each successive test.

In case of multiple string insulator sets (Vee, double etc.), the arcs in one test sequence shall always be initiated on the same string. This string shall be chosen in such a manner that the normal displacement of the arc due to electromagnetic forces is towards the other string(s) of the insulator set.

9 Ambient conditions

The wind velocity and all other ambient conditions (atmospheric pressure, rain, humidity and temperature) shall be recorded in all cases.

As the wind has an influence on the arc movement, the tests may be carried out in a test chamber or, when performed outdoors, shall be in calm weather whenever possible. To enable efficient comparison of lower current power arc tests (<10 kA), a maximum wind speed of 5 m/s is allowed.

Annex E gives the explanation of the importance of wind on power arc tests.

Other atmospheric conditions, including rain, are considered to have no significant influence on the results.

10 Test series and characteristics of the power arcs

In accordance with table 1 and figure 1, the X or Y test series from table 2 shall be chosen, depending on the type of the tower. To choose the test series Y is reasonable only if the return circuit is always unbalanced, for example when the tower does not have a centre phase window. For practical purposes, in applications where different tower geometries exist and would normally require both X and Y test series, the X series shall be chosen in preference, this being more stringent (this means that if the test series X has been performed, then series Y is covered).