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2005-10

Polymeric insulators for indoor and outdoor use with a nominal voltage >1 000 V – General definitions, test methods and acceptance criteria



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**POLYMERIC INSULATORS FOR INDOOR AND OUTDOOR USE
WITH A NOMINAL VOLTAGE >1 000 V –
GENERAL DEFINITIONS, TEST METHODS
AND ACCEPTANCE CRITERIA**

FOREWORD

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International Standard IEC 62217 has been prepared by IEC technical committee 36: Insulators.

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

FDIS	Report on voting
36/244/FDIS	36/245/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 maintenance result 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Polymeric insulators consist either of one insulating material (resin insulators) or two or several insulating materials (composite insulators). The insulating materials are generally cross-linked organic materials synthesized from carbon or silicon chemistry and form the insulating body. Insulating materials can be composed from organic materials containing various inorganic and organic ingredients, such as fillers and extenders. End fittings are often used at the ends of the insulating body to transmit mechanical loads. Despite these common features, the materials used and the construction details employed by different manufacturers may be widely different.

Some tests have been grouped together as "design tests", to be performed only once for insulators of the same design. The design tests are intended to eliminate insulator designs, materials or manufacturing technologies which are not suitable for high-voltage applications. The influence of time on the electrical properties of the complete polymeric insulator and its components (core material, housing, interfaces, etc.) has been considered in specifying the design tests in order to ensure a satisfactory life-time under normal operating and environmental conditions.

Pollution tests, according to IEC 60507 or IEC 61245, are not included in this International Standard, their applicability to composite insulators not having been proven. The results of such pollution tests performed on insulators made of polymeric materials do not correlate with experience obtained from service. Specific pollution tests for polymeric insulators are still under consideration.

The tracking and erosion tests given in this standard are considered as screening tests intended to reject materials or designs which are inadequate. These tests are not intended to predict long-term performance for insulator designs under cumulative service stresses. For more information, see Annex C.

Composite insulators are used in both a.c. and d.c. applications. In spite of this fact a specific tracking and erosion test procedure for d.c. applications as a design test has not yet been defined and accepted. The 1 000 h a.c. tracking and erosion test described in this standard is used to establish a minimum requirement for the tracking resistance of the housing material.

IEC Guide 111 has been followed during preparation of this standard wherever possible.

POLYMERIC INSULATORS FOR INDOOR AND OUTDOOR USE WITH A NOMINAL VOLTAGE >1 000 V – GENERAL DEFINITIONS, TEST METHODS AND ACCEPTANCE CRITERIA

1 Scope and object

This International Standard is applicable to polymeric insulators whose insulating body consists of one or various organic materials. Polymeric insulators covered by this standard include both solid core and hollow insulators. They are intended for use on overhead lines and in indoor and outdoor equipment with a rated voltage greater than 1 000 V.

The object of this standard is

- to define the common terms used for polymeric insulators,
- to prescribe common test methods for design tests on polymeric insulators,
- to prescribe acceptance or failure criteria, if applicable,
- to give recommendations for polymeric insulator test standards or product standards, complemented by specific requirements as needed.

These tests, criteria and recommendations are intended to ensure a satisfactory life-time under normal operating and environmental conditions (see Clause 5).

2 Normative references

The following referenced documents are indispensable for the application 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 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-11, *Basic environmental testing procedures – Part 2: Tests, Test KA: Salt mist*

IEC 60507, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

IEC 60815, *Guide for the selection of insulators in respect of polluted conditions*

IEC Guide 111, *Electrical high-voltage equipment in high-voltage substations – Common recommendations for product standards*

ISO 868, *Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 4287, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General Guidance*

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

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

3 Terms and definitions

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

3.1

polymeric insulator

insulator whose insulating body consists of at least one organic based material.

NOTE Coupling devices may be attached to the ends of the insulating body

NOTE Polymeric insulators are also known as non-ceramic insulators.

[IEV 471-01-13]

3.2

resin insulator

polymeric insulator whose insulating body consists of a solid shank and sheds protruding from the shank made from only one organic based housing material (e.g. cycloaliphatic epoxy)

3.3

composite insulator

insulator made of at least two insulating parts, namely a core and a housing equipped with metal fittings

NOTE Composite insulators, for example, can consist either of individual sheds mounted on the core, with or without an intermediate sheath, or alternatively, of a housing directly moulded or cast in one or several pieces on to the core.

[IEV 471-01-02]

3.4

core (of an insulator)

central insulating part of an insulator which provides the mechanical characteristics

NOTE The housing and sheds are not part of the core.

[IEV 471-01-03]

3.5

insulator trunk

central insulating part of an insulator from which the sheds project.

NOTE Also known as shank on smaller insulators.

[IEV 471-01-11]

3.6

housing

external insulating part of composite insulator providing necessary creepage distance and protecting core from environment

NOTE An intermediate sheath made of insulating material may be part of the housing.

[IEV 471-01-09]

3.7

shed (of an insulator)

insulating part, projecting from the insulator trunk, intended to increase the creepage distance. The shed can be with or without ribs

[IEV 471-01-15]

3.8

creepage distance

shortest distance or the sum of the shortest distances along the surface on an insulator between two conductive parts which normally have the operating voltage between them

NOTE 1 The surface of cement or of any other non-insulating jointing material is not considered as forming part of the creepage distance.

NOTE 2 If a high resistance coating is applied to parts of the insulating part of an insulator, such parts are considered to be effective insulating surfaces and the distance over them is included in the creepage distance.

[IEV 471-01-04]

3.9

arcing distance

shortest distance in air external to the insulator between the metallic parts which normally have the operating voltage between them

[IEV 471-01-01]

3.10

interfaces

surface between the different materials

NOTE Various interfaces occur in most composite insulators, e.g.

- between housing and end fittings,
- between various parts of the housing, e.g. between sheds, or between sheath and sheds,
- between core and housing.

3.11

end fitting

integral component or formed part of an insulator intended to connect it to a supporting structure, or to a conductor, or to an item of equipment, or to another insulator

NOTE Where the end fitting is metallic, the term “metal fitting” is normally used.

[IEV 471-01-06, modified]

3.12

connection zone

zone where the mechanical load is transmitted between the insulating body and the end fitting

3.13

coupling (of an insulator)

part of the end fitting which transmits load to the hardware external to the insulator

3.14

tracking

process which forms irreversible degradation by formation of conductive paths (tracks) starting and developing on the surface of an insulating material

NOTE These paths are conductive even under dry conditions.

3.15

erosion

irreversible and non-conducting degradation of the surface of the insulator that occurs by loss of material which can be uniform, localized or tree-shaped

NOTE Light surface traces, commonly tree-shaped, can occur on composite insulators as on ceramic insulators, after partial flashover. These traces are not considered to be objectionable as long as they are non-conductive. When they are conductive they are classified as tracking

3.16**crack**

any internal fracture or surface fissure of depth greater than 0,1 mm

3.17**puncture** (of an insulator)

permanent loss of dielectric strength due to a disruptive discharge passing through the solid insulating material of an insulator

[IEV 471-01-14]

4 Identification

The manufacturer's drawing shall show the relevant dimensions and information necessary for identifying and testing the insulator in accordance with this standard and the applicable IEC product standard(s). The drawing shall also show applicable manufacturing tolerances.

Each insulator shall be marked with the name or trade mark of the manufacturer and the year of manufacture. In addition, each insulator shall be marked with the rated characteristics specified in the relevant IEC product standards. These markings shall be legible, indelible and their fixings (if any) weather- and corrosion-proof.

5 Environmental conditions

The normal environmental conditions to which insulators are submitted in service are defined according to Table 1.

When special environmental conditions prevail at the location where insulators are to be put in service, they shall be specified by the user by reference to IEC 60721-1.

Table 1 – Normal environmental conditions

Condition	Indoor insulation	Outdoor insulation
Maximum ambient air temperature	Does not exceed 40 °C and its average value measured over a period of 24 h does not exceed 35 °C	
Minimum ambient air temperature	–25 °C	–40 °C
Vibration	Negligible vibration due to causes external to the insulators or to earth tremors ^a	
Solar radiation ^b	To be neglected	Up to a level of 1 000 W/m ²
Pollution of the ambient air	No significant pollution by dust, smoke, corrosive and/or flammable gases, vapours, or salt	Pollution by dust, smoke, corrosive gases, vapours or salt may occur. Pollution does not exceed "heavy" as defined in IEC 60815
Humidity	The average value of the relative humidity, measured over a period of 24 h, does not exceed 95 %; measured over a period of one month, does not exceed 95 %. For these conditions, condensation may occasionally occur	
^a Vibration due to external causes can be dealt with in accordance to IEC 60721-1.		
^b Details of solar radiation are given in IEC 60721-1.		

6 Information on transport, storage and installation

Manufacturers of insulators shall provide appropriate instructions and information covering general conditions during transport, storage and installation of the insulators. These instructions can include recommendations for cleaning or maintenance.

7 Classification of tests

The tests are divided into four groups as follows:

7.1 Design tests

The design tests are intended to verify the suitability of the design, materials and method of manufacture (technology).

A polymeric insulator design is generally defined by

- materials of the core, housing and manufacturing method,
- material of the end fittings, their design and method of attachment,
- layer thickness of the housing over the core (including a sheath where used).

Additional parameters defining design may be given in the relevant product standard.

When changes in the design of a polymeric insulator occur, re-qualification shall be carried out according to the requirements of the relevant product standard. Typically, only part of the tests are repeated. A survey of the tests is given in Annex D.

When a polymeric insulator is submitted to the design tests, it becomes a parent insulator for a design class and the results shall be considered valid for the whole class. This tested parent insulator defines a design class of insulators which have the following characteristics:

- a) same materials for the core and housing and same manufacturing method;
- b) same material as for the end fittings, same design and same method of attachment;
- c) same or greater minimum layer thickness of housing over the core (including a sheath where used).

Additional parameters to define a class of design may be given in the relevant product standard.

7.2 Type tests

The type tests are intended to verify the main characteristics of a polymeric insulator, which depend mainly on its shape and size. Type tests shall be applied to polymeric insulators belonging to an already qualified design class. The type tests shall be repeated only when the type of polymeric insulator is changed. The parameters defining a type of polymeric insulator are given in the relevant product standard.

The applicable type tests are given in the relevant product standard.

7.3 Sample tests

The sample tests are intended to verify the characteristics of polymeric insulators which depend on the quality of manufacture and on the materials used. They are made on insulators taken at random from lots offered for acceptance.

The applicable sample tests are given in the relevant product standard.

7.4 Routine tests

These tests are intended to eliminate polymeric insulators with manufacturing defects. They are carried out on every insulator to be supplied.

The applicable routine tests are given in the relevant product standard.

8 General requirements for insulator test specimens

Insulator test specimens for tests of polymeric insulators shall be checked prior to tests:

- for correct assembly, for example by applying the mechanical routine test specified in the relevant product standard,
- by visual examination according to the relevant product standard;
- for conformance of dimensions with the actual drawing.

For dimensions d without tolerances the following tolerances are acceptable:

- $\pm (0,04 \times d + 1,5)$ mm when $d \leq 300$ mm;
- $\pm (0,025 \times d + 6)$ mm when $d > 300$ mm with a maximum tolerance of 50 mm.

The measurement of creepage distances shall be related to the design dimensions and tolerances as determined from the insulator drawing, even if this dimension is greater than the value originally specified. When a minimum creepage is specified, the negative tolerance is also limited by this value.

In the case of insulators with creepage distance exceeding 3 m, it is allowed to measure a short section around 1 m long of the insulator and to extrapolate.

The housing colour of the test specimens shall be approximately as specified in the drawing.

The number of test specimens, their selection and dimensions are specified in the relevant clauses of this standard or in the relevant test standards.

9 Design tests

9.1 General

The following tests are normally classified as design tests, unless otherwise specified in the relevant product standard.

The design tests shall be performed only once according to the relevant product standard and the results shall be recorded in a test report.

Each test (9.2, 9.3, 9.4 and 9.5) can be performed independently on new test specimens, where appropriate, according to the test sequence given in the relevant test standard. The polymeric insulator of a particular design shall be deemed qualified only when all insulators or test specimens pass all the design tests specified in the relevant product standard.

9.2 Tests on interfaces and connections of end fittings

The test sequence consists of the following:

- reference dry power frequency test (9.2.3);
- pre-stressing (9.2.4);
- verification test (9.2.6).

9.2.1 Test specimens

For this series of tests, insulators assembled on the production line shall be selected. The number of specimens and their dimensions shall be in accordance with the relevant product standard. They shall be checked and tested as indicated in Clause 8.

If the manufacturer only has facilities to produce insulators with one or more dimensions smaller than indicated in the relevant product standard, the design tests may be performed on insulators of those dimensions available to him, however the results are only valid for other insulators of the same design class up to the dimensions tested.

9.2.2 Reference voltage and temperature for verification tests

For time or economic reasons, the reference dry power frequency test in 9.2.3 at the beginning of the test sequence may be omitted if an additional reference test specimen is used with properties as indicated in 9.2.1. The dry power frequency voltages after pre-stressing according to 9.2.6.3 and the shank temperature shall be compared either with the values of the reference test specimen or with the voltages determined prior to pre-stressing. It is clearly understood that the reference test specimen shall be not submitted to pre-stressing.

9.2.3 Reference dry power frequency test

The reference dry power frequency external flashover voltage shall be determined by averaging five flashover voltages, determined according to IEC 60060-1, on the test specimens or on the reference test specimen. This average flashover voltage shall be corrected to standard conditions in accordance with IEC 60060-1. The flashover voltage shall be obtained by increasing the voltage linearly from zero to flashover within 1 min.

9.2.4 Product specific pre-stressing

The test specimens shall be subjected to pre-stressing (e.g. thermal-mechanical) according to the relevant product standard.

9.2.5 Water immersion pre-stressing

The specimens shall be kept immersed in a vessel, in boiling de-ionized water with 0,1 % by weight of NaCl, for 42 h. Alternatively, tap water may be used with salt added to obtain a conductivity of $1\,750\ \mu\text{S}/\text{cm} \pm 80\ \mu\text{S}/\text{cm}$ at 20 °C. For a different water temperature, the conductivity correction as given in IEC 60507, Clause 7 shall be applied.

At the end of boiling, the specimens are allowed to cool and shall remain in water until the verification tests start in the following sequence. If transport is necessary in this period, the wet insulators may be put in sealed plastic bags or another suitable container for a maximum of 12 h.

9.2.6 Verification tests

The time interval between the following individual tests shall be such that the verification tests are completed within 48 h.

9.2.6.1 Visual examination

The housing of each specimen is inspected visually. No cracks are permissible.

9.2.6.2 Steep-front impulse voltage test

9.2.6.2.1 Procedure

The test specimens shall be fitted with sharp-edged electrodes (consisting of clips, e.g. made of a copper strip approximately 20 mm wide and less than 1 mm thick). These electrodes are fitted firmly around the housing between sheds so positioned to form sections of axial length of about 500 mm or smaller. The voltage shall be applied to the original metal fittings in case of insulators with a distance between end fittings smaller than, or equal to, 500 mm.

An impulse voltage with a steepness of at least 1 000 kV/ μ s shall be applied between two neighbouring electrodes or between the metal fitting and the neighbouring electrode, respectively. Each section shall be stressed individually with 25 impulses of positive and 25 impulses of negative polarity. Means shall be employed to prevent internal flashover of hollow insulators.

9.2.6.2.2 Acceptance criteria

Each impulse shall cause external flashover between the electrodes. No puncture of any part of the insulator shall occur.

9.2.6.3 Dry power frequency voltage test

9.2.6.3.1 Procedure

Before commencing the flashover test, the shank temperature on all test specimens shall be determined (reference temperature).

The dry power frequency voltage shall be determined by averaging five flashover voltages on each specimen. The average flashover voltage shall be corrected to normal standard atmospheric conditions in accordance with IEC 60060-1. The flashover voltage shall be obtained by increasing the voltage linearly from zero within 1 min.

Using the same method, determine the value of the reference flashover voltage using an additional reference test specimen, if available.

The test specimens and the reference test specimen, if applicable, shall then be continuously subjected for 30 min to 80 % of the reference flashover voltage.

The temperature of the housing between the sheds of each test specimen and of the reference insulator, if applicable, shall be measured at three places along or around the insulator immediately after the removal of the test voltage.

9.2.6.3.2 Acceptance criteria

The flashover voltage of each of the test specimens shall be greater than or equal to 90 % of the reference flashover voltage or the flashover voltage of the reference test specimen, respectively.

No puncture of any part of the insulator shall occur and the maximum temperature rise of each insulator housing between the sheds with respect to the temperature of the reference test specimen shall be less than 10 K. In cases where there is no reference test specimen then the maximum temperature rise shall be less than 20 K compared to the reference temperature determined prior to the power frequency tests.

9.3 Tests on shed and housing material

9.3.1 Hardness test

9.3.1.1 Procedure

Two specimens of the housing material of a size, shape and thickness appropriate for the hardness measurement method given in ISO 868 shall be taken from the housing of two insulators. If the shed shape or thickness is inappropriate, then samples may be made separately using the same manufacturing process and parameters.

Measure and record the ambient temperature and the hardness of the two samples in accordance with ISO 868 with a Shore A or D durometer, as appropriate.

The samples shall then be kept immersed in boiling water as defined in 9.2.5 for 42 h. The boiling container shown in Figure 1 is suitable for this boiling.

At the end of the boiling period, the samples shall be allowed to cool and, within 3 h, their hardness shall be measured again at the same temperature as that of the pre-boiling measurements ± 5 K.

9.3.1.2 Acceptance criteria

The hardness of each specimen shall not change from the pre-boiled value by more than ± 20 %.

9.3.2 Accelerated weathering test

9.3.2.1 Procedure

Select three specimens of shed and housing materials for this test (with markings included, if applicable).

The insulator housing material shall be subjected to a 1 000 h UV light test using one of the following test methods. Markings on the housing, if any, shall be directly exposed to UV light:

- Xenon-arc methods: ISO 4892-1 and ISO 4892-2, using method A without dark periods standard spray cycle black-standard/black panel temperatures of 65 °C an irradiance of around 550 W/m²
- Fluorescent UV method: ISO 4892-1 and ISO 4892-3, using type I fluorescent UV lamp exposure method 1 or 2.

NOTE An increased duration for the fluorescent UV test method is under consideration by CIGRE SC D1.

9.3.2.2 Acceptance criteria

After the test, markings on shed or housing material shall be legible; surface degradations such as cracks and raised areas are not permitted.

In case of doubt concerning such degradation, two surface roughness measurements shall be made on each of the three specimens. The roughness, R_z as defined in ISO 4287, shall be measured along a sampling length of at least 2,5 mm. R_z shall not exceed 0,1 mm.

NOTE ISO 3274 give details of surface roughness measurement instruments.

9.3.3 Tracking and erosion test

Two standard tests (1 000 h salt fog test, wheel test (Annex A)) are described. A third test method includes more multiple stresses (Annex B). One of the three test methods shall be chosen to verify the resistance of an insulator design to the stress of electrical discharge activity.

9.3.3.1 1 000 h salt fog test

9.3.3.1.1 Procedure

9.3.3.1.1.1 General

The test is a time-limited continuous test in salt fog at constant power-frequency voltage.

9.3.3.1.1.2 Test chamber

The test is carried out in a moisture-sealed corrosion-proof chamber, the volume of which shall not exceed 15 m³. An aperture of not more than 80 cm² shall be provided for the natural exhaust air.

9.3.3.1.1.3 Fog generation

A turbo sprayer (room humidifier) of constant spraying capacity shall be used as a water atomizer forming water droplets of a size of 5 µm to 10 µm. Alternatively, nozzles producing water droplets of the same size may be used. The IEC 60507 salt fog spray nozzles are not suitable for this test. The sprayer or nozzles are mounted close to the bottom of the chamber and spray upwards towards the roof of the chamber. The fog shall fill up the chamber and not be directly sprayed on to the test specimen. Salt water prepared from NaCl and de-ionized water shall be supplied to the sprayer (see Table 2). The fog intensity and uniformity shall be maintained in the specimen's exposure zone.

9.3.3.1.1.4 Fog calibration

The calibration shall be carried out at the start of the test.

At least two clean collecting receptacles with a collecting area of 8 000 mm² ± 2 000 mm² and a maximum height of 100 mm each are placed as close as practical to the position of the ends of the test object. The receptacles shall be positioned in such a way that they are not shielded by the test specimens and to avoid dripping from the construction elements of the chamber or another source.

They shall collect between 1,5 ml and 2,0 ml of precipitation per hour (corrected to 8 000 mm² collecting area) averaged over a minimum period of 16 h according to IEC 60068-2-11.

NOTE The flow rate necessary to obtain such precipitation (typically of the order of 0,3 l/m³h) should be noted. (The water flow rate is defined in litres per hour and per cubic meter of the test chamber volume.) Subsequently during the test, the flow rate should be checked at least every 100 h and remain within ±25 % of the initial value.

It is not permitted to re-circulate the water.

9.3.3.1.1.5 Test specimens

Two test insulators of identical design with a creepage distance between 500 mm and 800 mm shall be taken from the production line. If such insulators cannot be taken from the production line, special test specimens shall be made from other insulators so that the creepage distance falls between the given values. These special test specimens shall be fitted with standard production end fittings.

The test specimens shall be cleaned with de-ionized water before starting the test. One test specimen shall be tested mounted horizontally (at approximately half the height of the chamber) and the second shall be mounted vertically. There shall be a clearance of at least 400 mm between parallel test specimens and between test specimens and the roof, the walls and the floor.

NOTE Up to two pairs of test specimens can be tested simultaneously.

9.3.3.1.1.6 Test voltage

The test voltage in kilovolts is adjusted to the actual creepage distance of the test specimens determined by dividing the creepage distance in millimetres by 34,6 (equal to a specific creepage distance of 20 mm/kV). The test circuit when loaded with a continuous resistive current of 250 mA (r.m.s.) during 1 s on the high voltage side shall experience a maximum voltage drop of 5 %. The protection level shall be set at 1 A (r.m.s.).

9.3.3.1.1.7 Test conditions

Duration of the test: 1 000 h.

Weekly interruptions of the test for inspection purposes, each of these not exceeding 1 h are permissible. Interruption periods shall not be counted in the test duration.

One longer interruption up to 60 h is allowed. An additional testing time of three times the duration of the interruption period shall be added. The final test report shall include all details of interruptions.

Ambient temperature: 20 °C ± 5 K .

Initial salt content of the water: According to Table 2.

Table 2 – Initial NaCl content of the water as a function of the specimen dimensions

Shank diameter mm	Initial NaCl content of water kg/m ³	
	$l/p \leq 3$	$l/p > 3$
< 50	8 ± 0,4	4 ± 0,2
50 to 150	4 ± 0,2	2 ± 0,1
> 150	2 ± 0,1	1 ± 0,1

l/p is the creepage distance divided by the arcing distance.

NOTE For insulators with longer creepage per length, the initial NaCl content is reduced in order to avoid flashovers during the 1 000 h test. This reduction in salinity is not regarded as decreasing the severity of the tracking and erosion test but chosen to avoid unnecessary interruptions of the procedure.

If more than one flashover occurs at the initial NaCl content, the test shall be re-started at a halved value of the NaCl content. The insulators are washed by tap water and the test re-started within 8 h (interruption times shall not be counted as part of the test duration). This may be repeated until interruptions no longer occur. The application of any of the above measures shall be noted.

The numbers of flashovers and trip-outs shall be recorded and noted in the test report.

9.3.3.1.1.8 Acceptance criteria

The test specimens of identical design shall be assessed together. The test is regarded as passed if, on both test specimens:

- no tracking occurs;
- for composite insulators, erosion depth is less than 3 mm and does not reach the core, if applicable;
- for resin insulators, erosion depth is less than 3 mm;
- no shed, housing or interface is punctured.

9.3.4 Flammability test

9.3.4.1 Procedure

This test is intended to check the housing material for ignition and self-extinguishing properties.

The test specimen and procedure shall be according to IEC 60695-11-10. Sample thickness shall be 3 mm.

9.3.4.2 Acceptance criteria

The test is passed if the test specimen belongs to category HB40 and V0. The acceptance category shall be recorded.

NOTE The resistance to flammability is determined by intrinsic material properties and the design of the insulation. The minimum requirement is based on the fact that the insulation material will not continue burning after ignition, e.g. by a power arc or due to electrical discharges. Amendment 1(1995) to the first edition of IEC 61109:1992 requires the flammability classification for housing materials, as part of the design tests, according to method FV of the first edition of IEC 60707:1981 which has since been replaced by Method B according to IEC 60695-11-10. The horizontal burning test HB in IEC 60707:1981 could not be carried out on thin flexible specimens such as polymer insulator housing material. Method A of IEC 60695-11-10 is now available and allows testing of such flexible specimens. It is known that the minimum requirement, for the purposes of this standard, is met by materials satisfying category V0. Presently it is unknown whether this applies also to materials which only satisfy HB40. Nevertheless, in certain applications, e.g. medium voltage distribution line insulators, materials which only meet the flammability classification HB40 show acceptable performance even though they do not pass the V0 criterion. According to IEC 60695-11-10, the results obtained with the horizontal burning (HB) and the vertical burning (VB) methods are not equivalent. But experience shows that generally materials passing V0 will pass HB40 as well; however the reverse is not guaranteed. The correlation between performance in different flammability tests, laboratory power arc tests and behaviour in service is currently under investigation by CIGRE SC D1.

9.4 Tests on the core material

To check the performance of core material against water penetration the following tests shall be carried out. These tests can be carried out on specimens either with or without housing material, according to the requirements of the relevant product standard.

9.4.1 Dye penetration test

9.4.1.1 Procedure

Ten samples shall be cut from a production line insulator making the cut approximately 90° to the long axis of the insulator with a diamond-coated circular saw blade under running cold water. The length of the samples shall be 10 mm ± 0,5 mm. Figure 2 shows examples of specimens. The cut surfaces shall be smoothed by means of fine abrasive cloth (grain size 180). The cut ends shall be clean and parallel.

The specimens shall be placed (fibres vertical) on a layer of steel or glass balls of same diameter (1 mm to 2 mm) in a vessel or tray. A dye, 1 % methyl or ethyl alcohol solution of a red/violet Methin dye (such as Astrazon or Basonil¹⁾), shall be poured into the vessel, its level being 2 mm to 3 mm higher than the level of the balls. The dye will rise by capillarity through the core. The time taken for the dye to rise through the specimens shall be measured.

NOTE This test can be omitted for resin insulators.

9.4.1.2 Acceptance criteria

The time taken for the dye to rise through the specimens shall be greater than 15 min.

9.4.2 Water diffusion test

9.4.2.1 General

The following tests shall be carried out to check the core material for resistance to water attack.

9.4.2.2 Test specimens

Six samples shall be cut from a production line insulator making the cut approximately 90° to the long axis of the insulator with a diamond-coated circular saw blade under running cold water. The length of the samples shall be 30 mm ± 0,5 mm. The cut surfaces shall be smoothed by means of fine abrasive cloth (grain size 180). The cut ends shall be clean and parallel. Figure 2 shows examples of samples obtained from the different types of insulators. If a round sample cannot be cut from resin insulators, then samples with a surface area of the end face of at least 100 mm² may be taken from the thickest part of the insulator.

9.4.2.3 Pre-stressing

The surfaces of the specimens shall be cleaned with isopropyl-alcohol and filter-paper immediately before boiling. The specimens shall be boiled in a suitable container (e.g. made of glass or stainless steel) for 100 h ± 0,5 h in deionized water with 0,1 % by weight of NaCl.

Specimens of only one core material shall be boiled together in the same container. An example of such a container is shown in Figure 1.

After boiling, the specimens shall be removed from the boiling container and placed in another container (e.g. made of glass or stainless steel) filled with tap water at ambient temperature for at least 15 min. The voltage test shall be carried out within the next 3 h after the removal of the specimens from the boiling container.

9.4.2.4 Voltage test

The voltage test shall be carried out with the assembly shown in Figure 3. A typical high-voltage circuit for the test is shown in Figure 4.

Immediately before the voltage test, the specimens shall be removed from the container and their surfaces dried with filter paper.

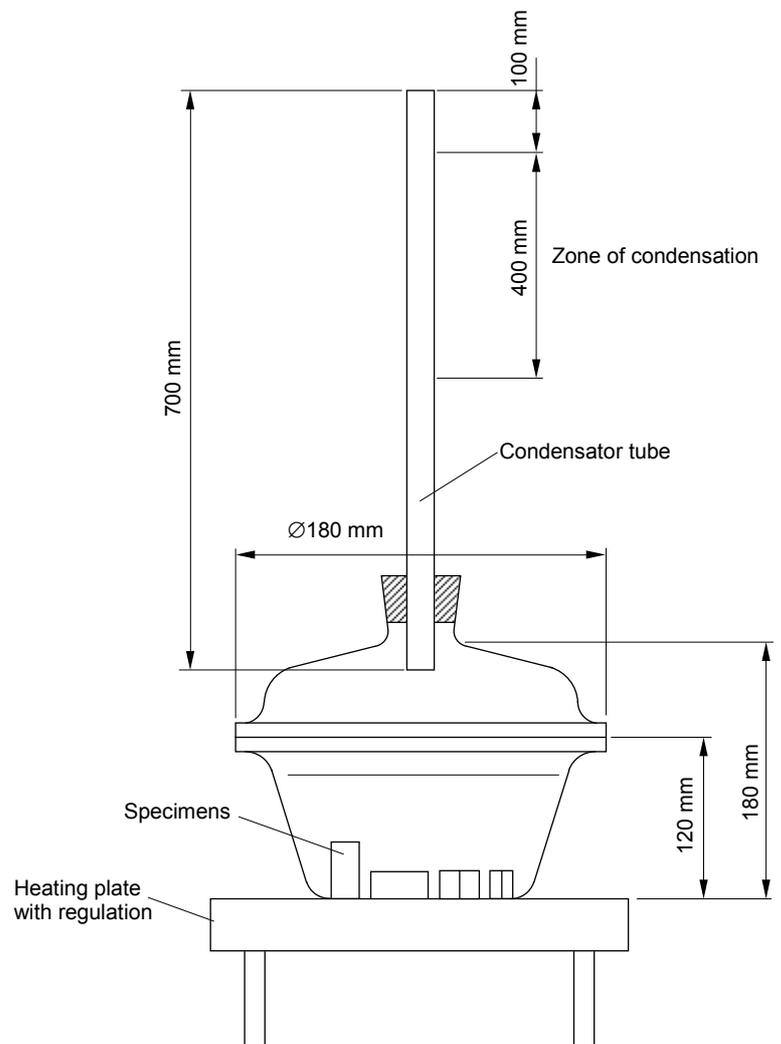
Each specimen shall then be put between the electrodes. The test voltage shall be increased at approximately 1 kV per second up to 12 kV. The voltage shall be kept constant at 12 kV for 1 min and then decreased to zero.

¹⁾ Astrazon and Basonil are examples of suitable products available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by IEC of these products.

9.4.2.5 Acceptance criteria

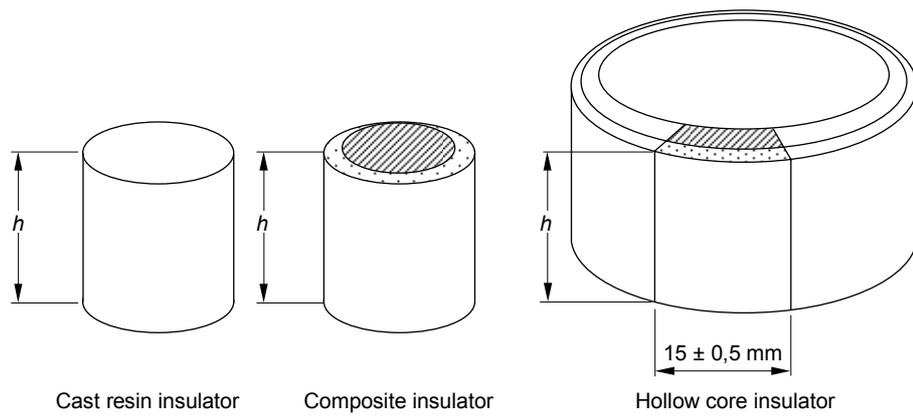
During the test no puncture or surface flashover shall occur. The current during the whole test shall not exceed 1 mA (r.m.s.).

Dimensions in millimetres



IEC 1956/05

Figure 1 – Example of boiling container for the water diffusion test



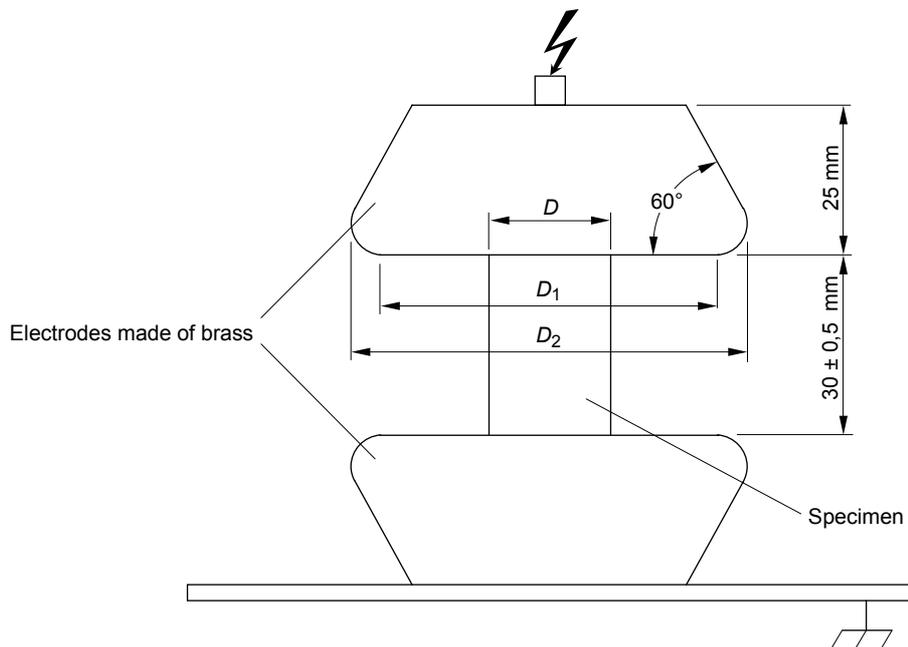
IEC 1957/05

Key

$h = 10 \text{ mm} \pm 0,5 \text{ mm}$ for samples for the dye penetration test
 $h = 30 \text{ mm} \pm 0,5 \text{ mm}$ for samples for the water diffusion test

Figure 2 – Examples of test specimen for core material

Dimensions in millimetres

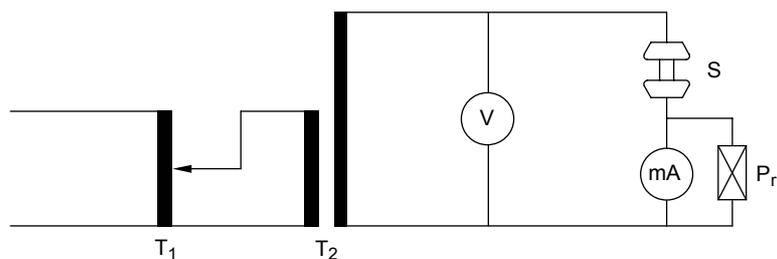


IEC 1958/05

$$D_1 \geq (D + 25 \text{ mm})$$

$$D_2 \geq (D_1 + 14 \text{ mm})$$

Figure 3 – Electrodes for the voltage test



IEC 1959/05

Components

T1 regulator

T2 high-voltage test transformer

V high-voltage measurement

mA milliamperemeter

Pr protection for the milliamperemeter

S electrodes with test-specimen

Figure 4 – Voltage test circuit

Annex A (normative)

Wheel test

A.1 Test specimens

Two test insulators of identical design with a creepage distance between 500 mm and 800 mm shall be taken from the production line. If such insulators cannot be taken from the production line, special test specimens shall be made from other insulators so that the creepage distance falls between the given values. These special test specimens shall be fitted with standard production end fittings.

Up to two pairs of test specimens can be tested simultaneously on one wheel. It is recommended not to mix widely differing materials on the same wheel.

A.2 Procedure

The test specimens shall be cleaned with de-ionized water before starting the test. The test specimens are mounted on the wheel as shown in Figure A.1 below. They go through four positions in one cycle. Each test specimen remains stationary for about 40 s in each of the four positions. The 90° rotation from one position to the next takes about 8 s. In the first part of the cycle the insulator is dipped into a saline solution. The second part of the test cycle permits the excess saline solution to drip off the specimen ensuring that the light wetting of the surface gives rise to sparking across dry bands that will form during the third part of the cycle. In that part the specimen is submitted to a power frequency voltage. In the last part of the cycle the surface of the specimen that had been heated by the dry band sparking is allowed to cool.

The test voltage is supplied by a test transformer. When loaded with a resistive current of 250 mA on the high voltage side the test circuit shall exhibit a maximum drop of 5 % in its output voltage.

The salt solution shall be replaced weekly. Weekly interruptions of the test for inspection purposes, each of these not exceeding 1 h are permissible. Interruption periods will not be counted in the test duration. One longer interruption up to 60 h is allowed. An additional testing time of three times the duration of the interruption period shall be added. The final test report shall include details of all interruptions.

A.3 Test conditions

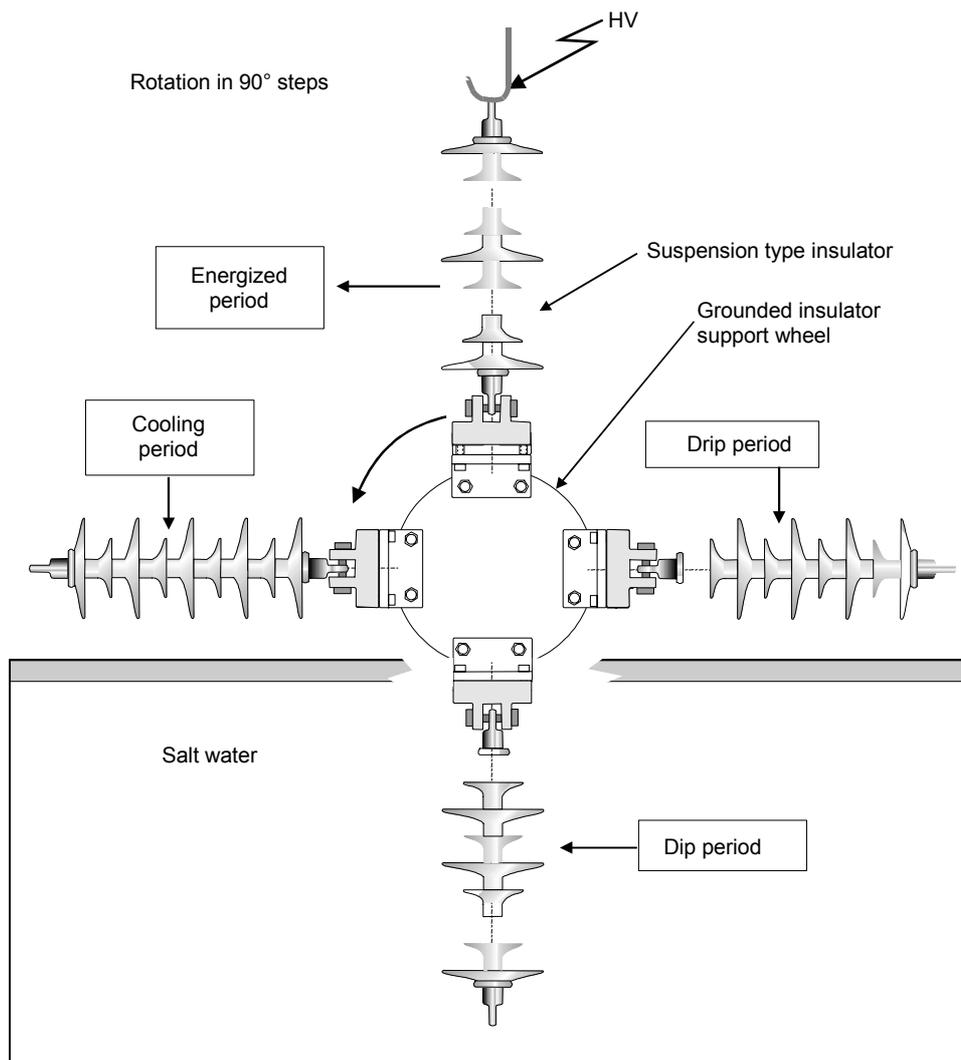
Electrical stress:	The power frequency test voltage in kV is determined by dividing the actual creepage distance in millimetres by 28,6.
NaCl content of de-ionized water:	1,40 kg/m ³ ± 0,06 kg/m ³
Ambient temperature:	20 °C ± 5 K
Test duration:	30 000 cycles

A.4 Acceptance criteria

The test specimens of identical design shall be assessed together. Pairs of test specimens of different design shall be assessed separately. The numbers of flashovers and trip-outs shall be recorded and noted in the test report.

The test is regarded as passed, if on both test specimens:

- no tracking occurs, (a megohmmeter shall be applied along any suspect path, using 1 kV DC or higher. The probes shall be between 5 mm to 10 mm apart. A resistance of less than 2 MΩ shall constitute failure);
- for composite insulators: erosion depth is less than 3 mm and does not reach the core, if applicable;
- for resin insulators: erosion depth is less than 3 mm;
- no shed, housing or interface is punctured.



IEC 1960/05

Figure A.1 – Test arrangement of the tracking wheel test

Annex B (normative)

Test at multiple stresses

B.1 Test specimen

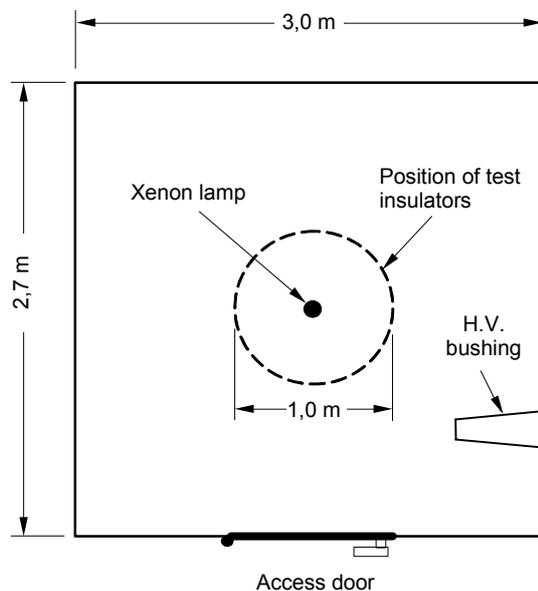
Two test insulators of identical design with a creepage distance between 500 mm and 800 mm shall be taken from the production line. If such insulators cannot be taken from the production line, special test specimens shall be made from other insulators so that the creepage distance falls between the given values. These special test specimens shall be fitted with standard production end fittings.

B.2 Procedure

The test shall be carried out in a moisture sealed corrosion-proof chamber, the volume of which shall not exceed 20 m³.

An example of a chamber is presented in Figure B.1.

Dimensions in millimetres



IEC 1961/05

**Figure B.1 — Typical layout of the test specimens in the chamber
and main dimensions of the chamber**

An insulated porthole equipped with a wiper and a mobile filter stopping ultraviolet radiation permits observation of the equipment on test.

NOTE Outside the chamber there are the following items: tanks of salt water and de-ionized water, together with the pumps, heaters, pipes for water and air, fans, the medium voltage step-up transformer, and its protections, the power supply to the ultraviolet radiation generator, all the electrical circuits and the devices for control, automatic control, measurement and regulation.

B.3 Test conditions

The cycle of stresses applied to the insulators and repeated for a period of 5 000 h is shown in Figure B.2. The cycle is designed so that the test specimens are also subjected to the effects of temperature variation and condensation.

The test specimens are arranged vertically in the chamber as shown in Figure B.3. There shall be a clearance of at least 400 mm between adjacent edges of the sheds of test specimens and between the test specimens and the roof, the walls and the floor.

The test specimens shall be cleaned with de-ionized water before starting the test.

Up to three pairs of test specimens with comparable creepage distance can be tested simultaneously.

Weekly interruptions of the test for inspection purposes, each of these not exceeding 1 h are permissible. Interruption periods shall not be counted in the test duration. Five longer interruptions up to 60 h each are allowed. An additional testing time of three times the duration of the interruption period shall be added. The final test report shall include all details of interruptions.

B.3.1 Voltage

The power frequency test voltage in kilovolts is adjusted to the actual creepage distance of the test specimens. It is determined by dividing the creepage distance in millimetres by 34,6 (equal to a specific creepage distance of 20 mm/kV, calculated as phase-to-phase value).

The supply circuit, when loaded with a continuous resistive current of 250 mA (r.m.s.) during 1 s on the high voltage side shall experience a maximum voltage drop of 5 %. The protection level shall be set at 1 A (r.m.s.).

B.3.2 Solar simulation

The simulated solar irradiation is provided by a xenon arc lamp with a nominal output of 6 500 W and equipped with 2 boron silicate glass filters (see example in Figure B.4). The distance between the xenon lamp and test specimens is approximately 480 mm.

A new lamp and filters shall be used at the beginning of each test. The filters, and if necessary the lamp, shall be replaced during the test according to the lamp manufacturer's recommendations.

B.3.3 Artificial rain

The artificial rain shall be provided by nozzles mounted above the test specimens and outside their perimeter (see Figure B.3). The average precipitation rate shall be in accordance with IEC 60060-1. Water of a minimum resistivity of 85 Ωm shall be used. Each of the test specimens is sprayed individually.

B.3.4 Dry heat

The chamber is heated up to 50 °C \pm 2 °C; the time for the temperature to rise is 15 min as a maximum.

NOTE It is recommended to heat and insulate the walls of the chamber.

B.3.5 Humid heat

Nominal relative humidity: $RH = 95 \% \pm 3 \%$ at $50\text{ }^{\circ}\text{C}$.

B.3.6 Pollution

The pollution is simulated by a salt fog (salinity: $7\text{ kg/m}^3 \pm 5\%$) sprayed by nozzles of the IEC 60507 type.

Each of the test specimens is sprayed individually.

Each spray nozzle is mounted below the corresponding test specimen and points upwards towards the centre of it, within an angle of $40^{\circ} \pm 10^{\circ}$ to the horizontal plane.

In case of unused test positions, insulators with comparable dimensions shall be placed at the unused positions and the corresponding spray nozzles shall be in service.

B.4 Salt fog calibration

To ensure the test reproducibility and the severity level of the salt fog, the salt fog shall be adjusted by using the method of calibration described below.

For this purpose a reference insulator is used. Its characteristics include:

- porcelain long rod insulator (hydrophilic material);
- normal shed profile (according to IEC 60815);
- creepage factor = $2,2 \pm 10\%$ (according to IEC 60815);
- shed diameter = $140\text{ mm} \pm 5\%$.

An example of a reference insulator is shown in Figure B.5.

The reference insulator shall be carefully cleaned so that traces of dirt and grease are removed.

Water, preferably heated to about $50\text{ }^{\circ}\text{C}$, with the addition of trisodium phosphate or another detergent, shall be used to wash the surface of the insulator. Subsequently, 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 the surface is completely hydrophilic.

After cleaning, the insulating parts of the insulator should not be touched by hand.

Before every calibration period, the insulator shall be again thoroughly washed with tap water only, in order to remove all traces of pollution.

The reference insulator shall be installed at each of the different test positions. Insulators with comparable dimensions shall be placed on the other test positions.

The power frequency test voltage in kilovolts is adjusted to the actual creepage distance of the reference insulator. It is determined by dividing the creepage distance in millimetres by 34,6 (equal to a specific creepage distance of 20 mm/kV , calculated as phase-to-phase value) within a tolerance of $\pm 5\%$.

All the salt fog nozzles shall be in service.

The fog (position of nozzles and flow rate) is adjusted to obtain an average level of the maximum peak currents (the maximum value recorded every 1 min), in the range 100 mA to 120 mA, measured during 4 h. An establishment time of the leakage current of 30 min maximum is permitted and not included in the calibration.

This is applied to all test locations.

Each test position can be calibrated separately. Alternatively, it is allowed to locate a reference insulator at each test position and to perform the calibration of all test positions simultaneously and independently. If the positions are calibrated individually, the calibration shall be repeated to ensure that the initial fog corrections have not influenced the neighbouring test positions.

B.5 Acceptance criteria

The test specimens of identical design shall be assessed together. The numbers of flashovers and trip-outs shall be recorded and noted in the test report.

The test is regarded as passed if, on both test specimens:

- no tracking occurs, (a megohmmeter shall be applied along a suspect path, using 1 kV DC or higher. The probes shall be between 5 mm to 10 mm apart. A resistance of less than 2 MΩ shall constitute failure);
- for composite insulators: erosion depth is less than 3 mm and does not reach the core, if applicable;
- for resin insulators: erosion depth is less than 3 mm;
- no shed, housing or interface is punctured.

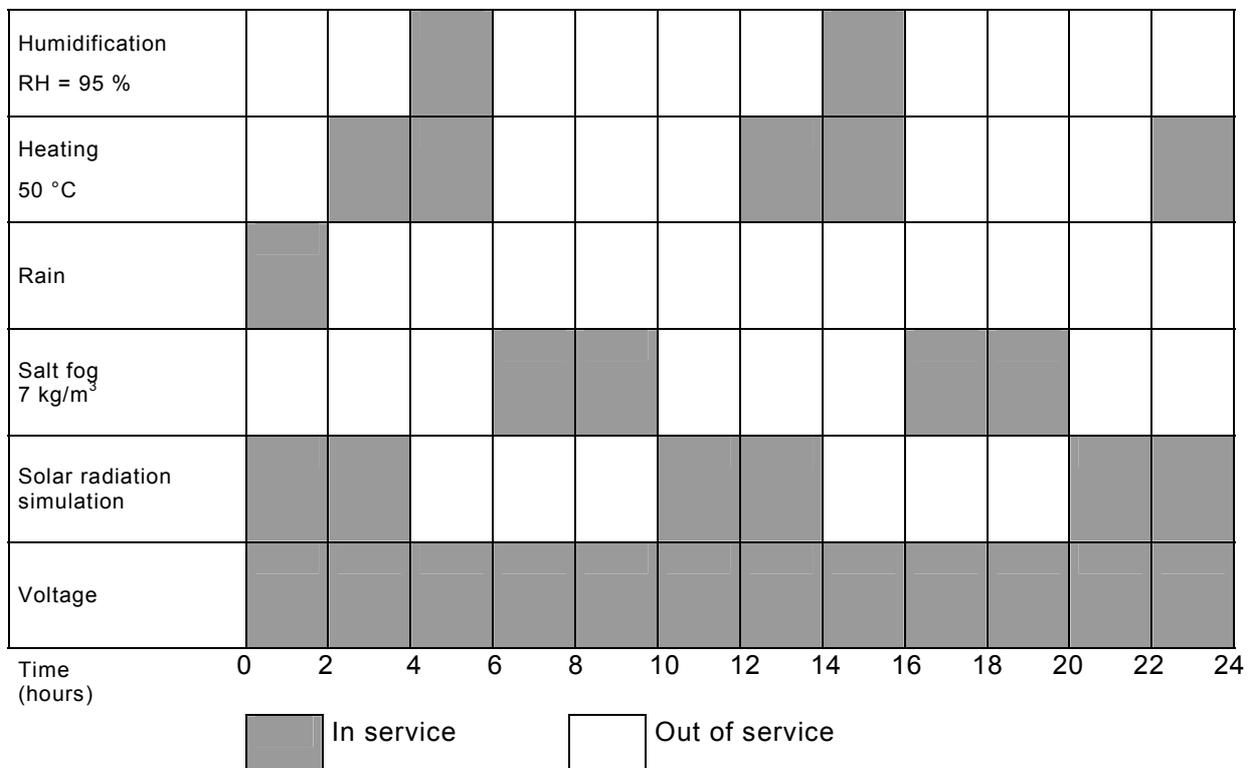
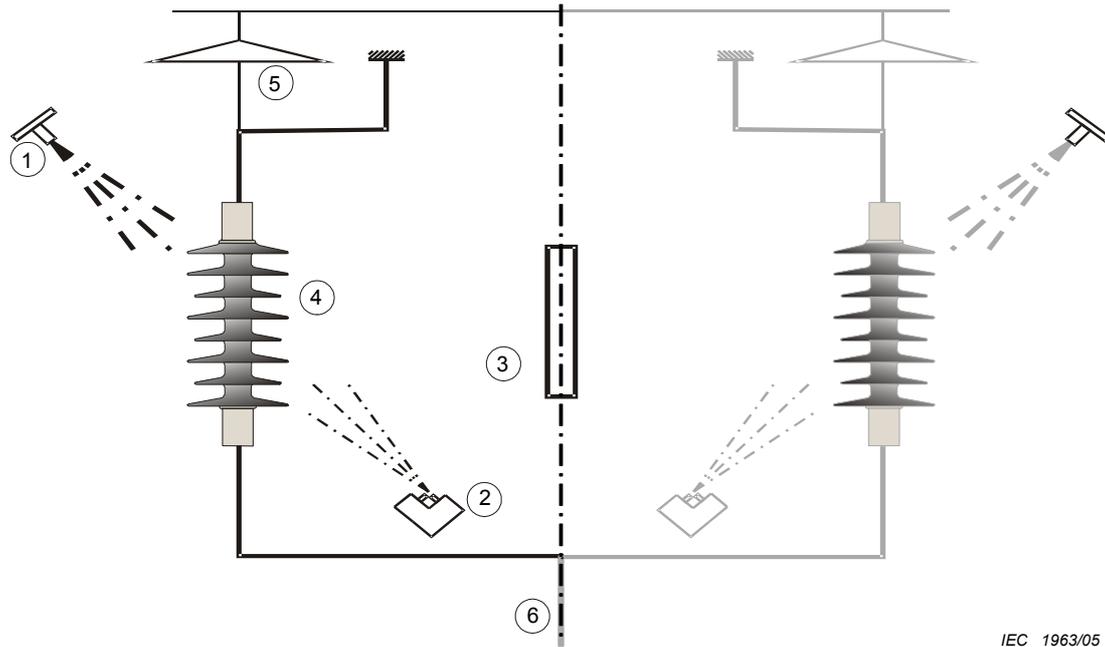


Figure B.2 – Multiple stress cycle

IEC 1962/05

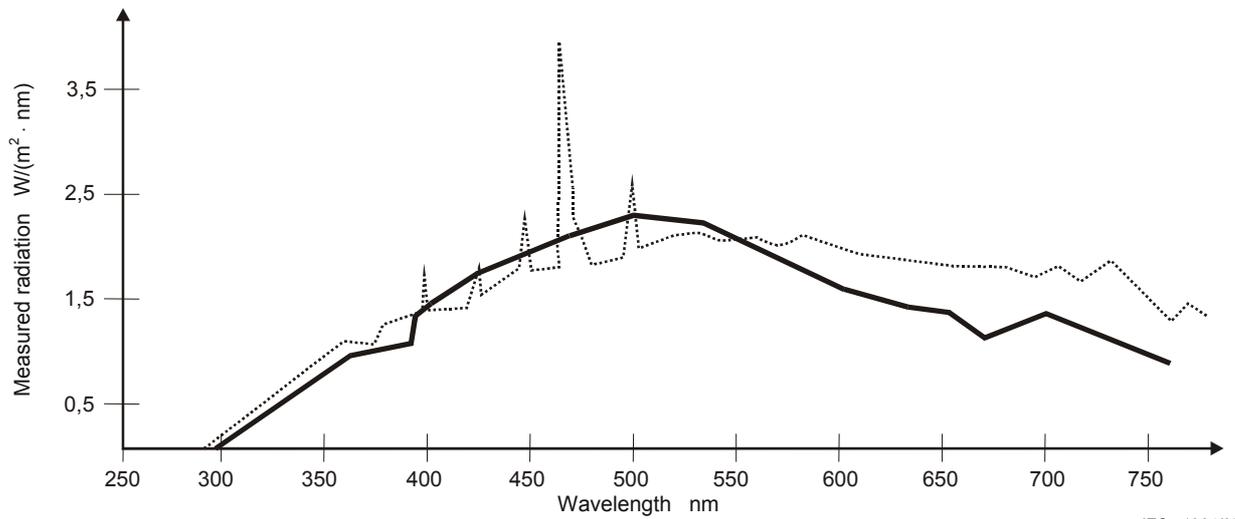


IEC 1963/05

Key

- | | |
|--|-----------------------|
| 1 rain nozzle | 4 test specimen |
| 2 salt fog spray nozzle (IEC 60507 type) | 5 isolating insulator |
| 3 xenon UV lamp | 6 HV power supply |

Figure B.3 – Typical layout of the rain and salt fog spray systems and the xenon lamp

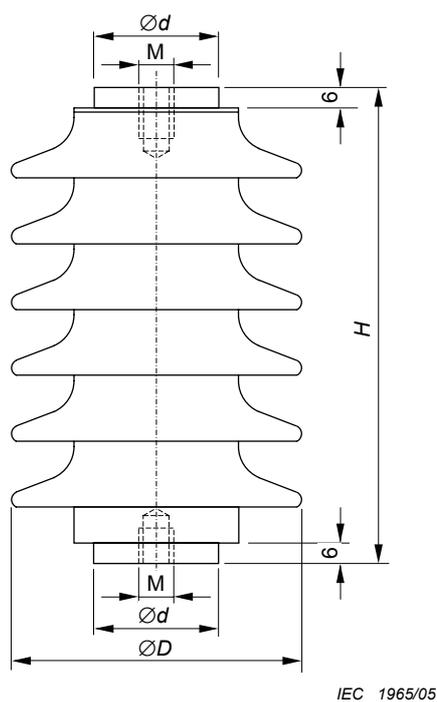


IEC 1964/05

Legend

- Spectrum of the xenon arc lamp equipped with two boron silicate filters.
- Solar spectrum at midday in June, latitude 42°.

Figure B.4 – Spectrum of xenon arc lamp and solar spectrum



Characteristics:

IEC ref:	H4-125
Nominal creepage distance:	500 mm
Dry arcing distance:	225 mm
Length H :	210 mm
Shed diameter D :	140 mm

Figure B.5 – Reference porcelain insulator

Annex C (informative)

Difference between the tracking and erosion and accelerated ageing tests on polymeric insulators

Although this standard describes several tracking and erosion tests which are often referred to in the literature as “ageing tests”, it is important to note that they are not accelerated ageing tests in the sense that these tests do not simulate exactly real life degradation conditions nor do they accelerate them to give a life equivalent test in a short time. Rather, they use continuous, cyclic or combined stresses to try to detect potential weaknesses which could compromise the insulators performance in service.

The relevant tests (9.3.3, Annex A and Annex B) are better described as screening tests, which can be used to reject materials, or designs, which are inadequate.

The ageing mechanisms on a polymeric insulator generally do not cause a progressive reduction of easily measurable ageing-induced properties over time. The transition from “good condition” to “end of life” is frequently sudden with no forewarning and might be observed by, for instance, erosion depths comparable to those obtained in the salt fog test referred to above, or deep UV-initiated cracks in the surfaces. The time and speed of this transition depends on multiple parameters, both of the insulator material and design, and of the operating environment. Hence the use of such ageing tests for true “end of life” prediction is only possible when relevant data on damage and degradation is available for the same or similar insulators in the same or similar environments.

These tests are used therefore to give a general indication of the quality of the design and materials with respect to the stresses arising in relatively harsh but not extreme environments.

It is important to note that the “end of test” pass criteria include levels of damage that would not be acceptable on insulators in most service environments. For instance in the relevant tests (9.3.3, Annex A and Annex B), erosion depths of up to 3 mm are acceptable in the test but they would not be acceptable in service, and they would not be expected in the projected lifetime of the insulator.

For further information, see CIGRE Technical Brochure No. 142: “ *Natural and artificial ageing and pollution testing of polymeric insulators.*” June 1999.

Annex D (informative)

Recommended application of tests

Clause	Test specification	Design tests for polymeric insulators			
		Outdoor insulators		Indoor insulators	
		Composite insulators	Resin insulators	Composite insulators	Resin insulators
9.2.4	Pre-stressing	X	X	X	X
9.2.5	Water immersion pre-stressing	X	X	X	
9.2.6	Verification tests	X	X	X	X
9.2.6.1	Visual examination	X	X	X	X
9.2.6.2	Steep-front impulse voltage test	X	X	X	X
9.2.6.3	Dry power frequency voltage test	X	X	X	X
9.3.1	Hardness test	X	X		
9.3.2	Accelerated weathering test	X	X		
9.3.3	Tracking and erosion test	X	X		
9.3.4	Flammability test	X	X	X	X
9.4.1	Dye penetration test	X		X	
9.4.2	Water diffusion test	X	X		

Annex E (informative)

Explanation of the concept of classes for the design tests

The design tests specified in Clause 9 are intended to verify the suitability of the design, materials and method of manufacture used by the manufacturer. They are necessarily time consuming and costly since they involve investigation of all major aspects that determine both the initial and the long term behaviour of the design. In order to avoid unnecessary testing, two methods have been used:

- a certain degree of freedom in design changes is allowed so that products can evolve without having to repeat all the design tests each time a minor change is made to the insulator design;
- insulators are divided into classes and the design tests are carried out on one representative of each class, the resulting certificate is then valid for all members of the class.

Tables in the relevant product standards give the list of tests to be repeated according to the design parameter which has been changed for the insulator serving as the representative for a design class. Note that there are tolerances implemented in these tables concerning housing profile parameters. However, once the housing profile of the representative insulator has changed beyond these tolerances, the appropriate design test will need to be repeated.

The choice of the insulator to be submitted to the design test to become a representative of a design class is left to the manufacturer, as is the denomination of the classes.

The general parameters which determine the membership of a design class are given in 7.1 a) to c). These parameters are not to be confused with those in the relevant tables specified in the product standards. Here the tolerances are expressed with respect to the characteristics of the representative insulator as noted on the test certificate. Any insulator falling within the limits given in this list is a member of the design class of the latter. No design testing is necessary for such an insulator.

Note that the tolerances, generally specified as 15 %, with 25 % on shed spacing, apply to all the housing profile parameters; hence, the range of possible profiles in a given design class can be quite large.

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Amendment 1 (1995)

IEC 61245, *Artificial pollution tests on high-voltage insulators to be used on d.c. systems*

ISO 3274, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Nominal characteristics of contact (stylus) instruments*

¹ Second edition (in preparation).

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