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Polymeric HV insulators for indoor and outdoor use - General definitions, test methods and acceptance criteria

Isolateurs polymériques à haute tension pour usage intérieur et extérieur - Définitions générales, méthodes d'essai et critères d'acceptation

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Polymeric HV insulators for indoor and outdoor use - General definitions, test methods and acceptance criteria

FOREWORD

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

This third edition cancels and replaces the second edition published in 2012. This edition constitutes a technical revision.

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

a) The scope of the document is specified to comprise composite insulators with solid and hollow core and resin insulators used for both AC and DC systems in indoor and outdoor applications of HV overhead lines and substations; hybrid insulators (defined in IEC TS 62896) with ceramic core and polymeric housing are also included, while coated insulators (e.g. with Room Temperature Vulcanized (RTV) silicone rubber coatings) are not considered in this document;

b) Steep-front impulse voltage test is modified to avoid unwanted flashovers between the leads of the electrodes;

c) Differences between hydrophobicity transfer material (HTM) and non-HTM housing materials are specified and relevant test methods and acceptance criteria for polymeric insulators with HTM housing are introduced;

d) The previous water diffusion test on core materials with or without housing is split into two tests. One is on core materials without housing, the other is on core materials with housing. The acceptance criteria are modified;

e) Stress corrosion test for core materials is introduced;

f) Annex B summarizes the test application for evaluating the quality of interfaces and connections of end fittings, housing materials and core materials;

g) Annex E is introduced to emphasize the need for control of electric fields of polymeric insulators for AC. The control of electric fields of polymeric insulators for DC is still under consideration.

The text of this International Standard is based on the following documents:

Draft	Report on voting
36/612/FDIS	36/631/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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 synthesised 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 manufacturers might differ significantly.

The tests given in this document are those which are, in general, common to a majority of insulator designs and materials, whatever their final application. Considering the increasing applications of polymeric insulators, the scope of this document specifies technical requirements for solid core, hollow core and resin insulators used in AC and DC systems, in indoor and outdoor, in applications of HV overhead lines and substations to ensure proper insulator performance under normal operating conditions. The technical requirements have been regrouped in this document to avoid repetition of the relevant product standards and drift between procedures as the various product standards are drafted or revised.

The majority of these 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 (HV) applications. The influence of time on the electrical properties of the complete polymeric insulator and its components (core, housing, interfaces etc.) has been considered in specifying the design tests in order to ensure a satisfactory lifetime under normal operating and environmental conditions. To ensure quality and reliable long-term performance of insulators, the requirements on the modification of certain test procedures as well as the introduction of new tests were identified.

Pollution tests, according to IEC 60507 or IEC TS 61245 [1][1], are not included in this document. Specific pollution tests for polymeric insulators are under consideration of IEC, indications for design considering pollution are given in IEC TS 60815-1, IEC TS 60815-3 [2] and IEC TS 60815-4 [3].

Before the appropriate standard for DC applications will be issued, the majority of tests listed in this document can also be applied to DC insulators. The 1 000 h AC salt fog tracking and erosion test is considered as a design test in this document to reject materials in combination with the design which are inadequate. For the time being, the 1 000 h AC salt fog tracking and erosion test is used to establish a minimum requirement for the tracking and erosion resistance, for both AC and DC. For DC applications, a specific DC tracking and erosion test procedure as a design test has not been developed. Further tracking and erosion test methods such as the 5 000 hour and the tracking wheel test are described in IEC TR 62730 [4] and can be used for research or other purposes. Tracking and erosion tests are not intended to evaluate long term performance of insulators in harsh environments by the simulation of multiple environmental factors. It is therefore necessary to carry out ageing tests for insulator designs under cumulative service stresses. These aging tests do not form part of this present document.

For polymeric insulators with hydrophobicity transfer property, relevant test procedures are introduced. In this document the hydrophobicity transfer test is intended to distinguish the HTM from non-HTM rather than differentiate between different HTMs degrees.

The water diffusion test is divided into two tests. The first one is for the core (as earlier), the second one is for the core with housing. The water diffusion test on core with housing addresses the interface between the core and the housing. The acceptance criteria are modified and harmonized for both tests.

[1] Numbers in square brackets refer to the Bibliography.

Stress corrosion test for insulators mainly subjected to tensile loads is introduced to minimize the risks of brittle fractures.

Annex B summarizes the test application for evaluating the quality of interfaces and connections of end fittings, housing materials and core materials.

Annex E is introduced to emphasize the need for the control of electric field of polymeric insulators under AC voltage.

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

1 Scope

This International Standard is applicable to polymeric insulators for AC systems with a nominal voltage greater than 1 000 V (frequency less than 100 Hz) and DC systems with a nominal voltage greater than 1 500 V whose insulating body consists of one or various organic materials. Polymeric insulators covered by this document are intended for use both on HV overhead lines and in substations, in both indoor and outdoor applications. They include composite insulators with solid and hollow core and resin insulators. Hybrid insulators with ceramic core and polymeric housing are also included, while coated insulators (e.g. with RTV silicone rubber coatings) are not included in this standard. Electrical tests described in this document are done under AC voltage and are in general applicable to insulators to be used in DC systems too. Tests under DC voltage are intended to reflect up-to-date knowledge and experience.

NOTE Only polymeric housing materials of hybrid insulators are specified in this document. Tests for core materials and the interfaces between housing and core of hybrid insulators are not included.

The object of this document 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;

These tests, criteria and recommendations are intended to ensure a satisfactory lifetime under normal operating and environmental conditions (see Clause 5). This document includes design tests intended to reject materials or designs which are inadequate under normal operating and environmental conditions. This document defines test methods and acceptance criteria. The applicable tests are given in the relevant product standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-471:2007, *International Electrotechnical Vocabulary (IEV) - Part 471: Insulators*

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

IEC 60507:2013+COR1:2018, *Artificial pollution tests on high-voltage ceramic and glass 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 TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles*

IEC TR 62039:2021, *Selection guidelines for polymeric materials for outdoor use under HV stress*

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

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

ISO 21920-2, *Geometrical product specifications (GPS) Surface texture: Profile - Part 2: Terms, definitions and surface texture parameters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-471:2007 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
high voltage
HV
voltage over 1 000 V AC or over 1 500 V DC or over 1 500 V peak value

3.2
polymeric insulator
insulator whose insulating body consists of at least one organic based material

Note 1 to entry: Polymeric insulators are also known as non-ceramic insulators.

Note 2 to entry: Coupling devices may be attached to the ends of the insulating body.

[SOURCE: IEC 60050-471:2007, 471-01-13]

3.3
resin insulator
polymeric insulator whose insulating body consists of a solid insulator trunk and sheds protruding from the insulator trunk made from only one organic based housing material (e.g. cycloaliphatic epoxy)

3.4
composite insulator
insulator made of at least two insulating parts, namely a core and a housing, equipped with end fittings

Note 1 to entry: 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.

[SOURCE: IEC 60050-471:2007, 471-01-02]

3.5
hybrid insulator
insulator that consists of a ceramic core and a polymeric housing, equipped with one or more metal fittings

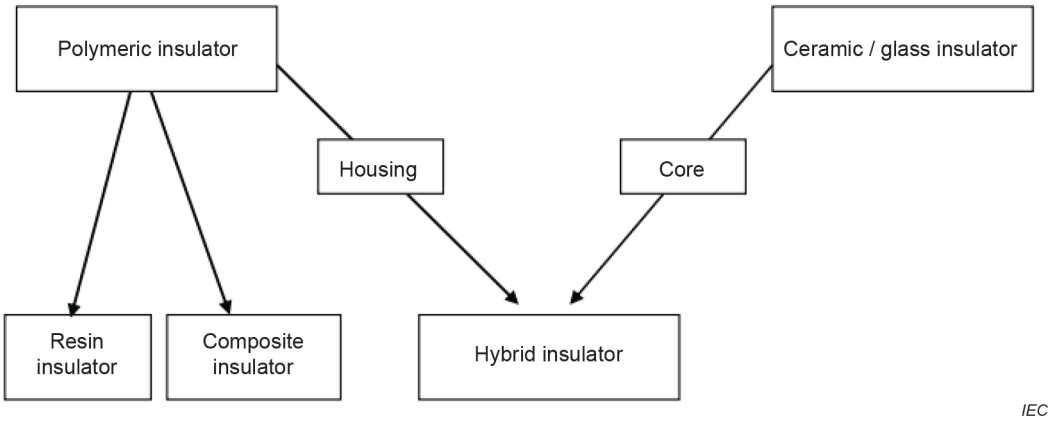

Figure 1 – Illustration of different types of insulators

SEE: Figure 1.

Note 1 to entry: According to IEC TS 62896 [5].

Note 2 to entry: The mechanical functions are mainly characterised by the core, the external electrical functions are mainly characterised by the polymeric housing. The housing may cover the core completely or partly. In the latter case the exposed portions of the ceramic core are usually covered by glaze.

3.6
composite insulator with fibre reinforced plastic (FRP) solid core
composite insulators of which the core, covered by polymeric housing, is made of solid insulating polymeric material reinforced by fibres such as glass fibres

3.7
composite hollow insulator
insulator consisting of at least two insulating parts, namely a tube-shaped core, and a housing

Note 1 to entry: The housing may consist either of individual sheds mounted on the tube, with or without an intermediate sheath, or directly applied in one or several pieces onto the tube. A composite hollow insulator unit is permanently equipped with fixing devices or end fittings.

3.8
core
central insulating part of an insulator which provides the mechanical characteristics

Note 1 to entry: The housing and sheds are not part of the core.

[SOURCE: IEC 60050-471:2007, 471-01-03]

3.9
insulator trunk
central insulating part of an insulator from which the sheds project

Note 1 to entry: Also known as shank on smaller insulators.

[SOURCE: IEC 60050-471:2007, 471-01-11]

3.10
housing
external insulating part of a composite insulator providing the necessary creepage distance and protecting core from environment

[SOURCE: IEC 60050-471:2007, 471-01-09]

3.11
sheath
uniform and continuous tubular covering made of insulating material

[SOURCE: IEC 60050-151:2001, 151-12-41]

3.12
shed (of an insulator)
insulating part, projecting from the insulator trunk, intended to increase the creepage distance

Note 1 to entry: The shed can be with or without ribs.

[SOURCE: IEC 60050-471:2007, 471-01-15]

3.13
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 to entry: The surface of cement or of other non-insulating jointing material is not considered as forming part of the creepage distance.

[SOURCE: IEC 60050-471:2007, 471-01-04, modified (removal of Note 2 to entry)]

3.14
arcing distance
shortest distance in air external to the insulator between the metallic parts which normally have the operating voltage between them

[SOURCE: IEC 60050-471:2007, 471-01-01]

3.15
interfaces
surface between the different materials

Note 1 to entry: Various interfaces exist in composite insulators, e.g.:

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

3.16
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 1 to entry: Where the end fitting is metallic, the term "metal fitting" is normally used.

[SOURCE: IEC 60050-471:2007, 471-01-06, modified by the addition of a synonym]

3.17
coupling
part of the end fitting which transmits load to the hardware external to the insulator

3.18
tracking
progressive formation of conductive paths, which are produced on the surface or within a solid insulating material, due to the combined effects of electric stress and electrolytic contamination

Note 1 to entry: Tracking paths are conductive even under dry conditions.

[SOURCE: IEC 60050-212:2010, 212-11-56, modified (addition of Note 1 to entry)]

3.19
erosion
loss of material by electrical discharge

Note 1 to entry: Surface traces, commonly tree-shaped, can occur on composite insulators as on ceramic and glass insulators, after exposure to surface discharges. When they are conductive they are classified as tracking.

3.20
crack
internal fracture or surface fissure of depth greater than 0,1 mm

3.21
puncture
permanent loss of dielectric strength due to a disruptive discharge passing through the solid insulating material of an insulator

[SOURCE: IEC 60050-471:2007, 471-01-14, modified to define puncture as the result of a discharge, rather than the discharge itself]

3.22
hydrophobicity
surface of a solid insulating material characterized by its capacity to repel water or aqueous electrolyte solutions

Note 1 to entry: Hydrophobicity of a polymeric insulating material is, in general, a volume property by means of the chemical composition of a material at its surface.

Note 2 to entry: Nonetheless, hydrophobicity is strongly affected by surface effects such as:

- surface structure (i. e. roughness);
- chemical interaction between water and the solid surface (adsorption, absorption, swelling of the solid material in contact with water);
- an accumulated pollution layer.

Note 3 to entry: Furthermore, the conditions during an evaluation of hydrophobicity (temperature, pressure, humidity), and the method for cleaning or electrostatic charges can affect the measured degree of hydrophobicity.

[SOURCE: IEC TR 62039: 2021, 3.1, modified (deleting of "climatic" in Note 3 to entry)]

3.23
hydrophobicity transfer
phenomenon of a transfer of hydrophobicity from the bulk of the housing material to pollution layer on its surface

3.24
hydrophobicity transfer material
HTM
polymeric material which exhibits hydrophobicity and the capability to transfer hydrophobicity onto the layer of pollution, which is a combined dynamic behaviour of retention and transfer of hydrophobicity specific to different insulator materials

[SOURCE: IEC TS 60815-4:2016 [3], 3.1.4, modified (addition of text from "which is …")]

4 Identification

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

Each insulator shall be marked with the name or trademark 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. Terms are defined as follows:

Table 1 – Normal environmental conditions

	Indoor insulation	Outdoor insulation
Maximum ambient air temperature[a]	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[b]	−25 °C	−40 °C
Vibration	Negligible vibration due to causes external to the insulators or to earth tremors[c].	
Solar radiation[d]	Not applicable	Up to a level of 1 120 W/m^2
Site pollution severity[e]	No significant pollution by dust, smoke, corrosive and/or flammable gases, vapors, or salt.	Pollution by dust, smoke, corrosive gases, vapors or salt occurs. Pollution does not exceed "heavy" SPS class as defined in IEC TS 60815-1.
Humidity[f]	No rain, snow, abnormal humidity, condensation, ice and hoar frost	Rain, snow, abnormal humidity, condensation, ice and hoar frost occur.

[a] If exceeded, follow the recommendations of IEC TR 62039 for the core and adhesive materials (like glue) in "glass transition temperature" section.

[b] In general, temperatures below −40 °C are non-critical for service. However, for handling and installation the crystallization temperature of the polymeric housing is to be considered. For line installations during wintertime with temperatures below −20 °C, special steel grades with low ductile transition temperature can be specified.

[c] Vibration due to external causes can be dealt with in accordance with IEC 60721-1.

[d] For outdoor application, the influence of deviation from the assumed level of 1 120 W/m^2 depends on the insulator material. If service conditions of polymeric insulators deviate significantly from the parameters in Table 1, the insulator is to be designed/evaluated taking into account relevant service experience. In the absence of significant service experience, special tests simulating the solar radiation condition of the installation area have to be carried out.

[e] In general, pollution is not an issue for indoor insulators. In particular cases, such as DC indoor conditions, the insulators can accumulate some contamination due to DC electric field. However, the pollution flashover phenomena cannot develop when the humidity is controlled. For outdoor conditions the requirements of this document are specified for stresses arising in relatively harsh but not extreme environments (see e.g. for hydrophobicity verification and tracking and erosion tests for which criteria are provided in IEC TR 62039).

[f] Insulator for indoor applications can also be used in presence of limited deviations from the above conditions if sufficient proven field experience is available and condensation occurs only occasionally. To limit condensation-related phenomena, the average value of the relative humidity condition, measured over a period of 24 h, shall not exceed 95 % and when measured over a period of one month, shall not exceed 90 %. Exceeding these values is considered as abnormal humidity condition.

- Indoor environment: installation within a building or other construction where the insulators are protected against wind, rain, snow, periodical fast-built pollution deposits, abnormal condensation, ice and hoar frost.
- Outdoor environment: installation in open air outside any building or shelter, where the insulators are capable to withstand wind, rain, snow, periodical fast-built pollution deposits, high condensation, ice and hoar frost.

If service conditions of polymeric insulators deviate significantly from the parameters in Table 1, the insulator is to be designed or evaluated according to agreement between the customer and manufacturer. Alternatively, if positive service experience is available for a specific environment and specific insulator design (including material and profile), the insulator can be used for this specific environment, deviating from normal environmental conditions.

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 and correct positioning and installation of the corona rings.

7 Classification of tests

7.1 General

The tests are divided into four groups as follows:

7.2 Design tests

The design tests are intended to verify the suitability of the design, materials and method of manufacturing (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 prescriptions of the relevant product standard. Typically, only part of the tests is repeated. Explanation of the concept of classes for the design tests is provided in Annex A.

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:

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

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