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TECHNICAL REPORT

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Selection guidelines for polymeric materials for outdoor use under HV stress

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CONTENTS

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SELECTION GUIDELINES FOR POLYMERIC MATERIALS FOR OUTDOOR USE UNDER HV STRESS

FOREWORD

IEC TR 62039 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

a) addition of hydrophobicity definitions and hydrophobicity transfer test;

b) addition of stress corrosion test.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
112/526/DTR	112/535/RVDTR

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 Technical Report 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/standardsdev/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- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

There is a need within utilities and industry for material standards that define the physical properties of the polymers applied for outdoor insulation. This requirement was identified during discussions in IEC TC 36 and IEC TC 112. As a consequence, in 2001, CIGRE formed the working group D1.14 and later on working groups D1.27, C4.303 and D1.58 with the specific task of defining the physical parameters which are important for the polymeric materials applied in outdoor insulation and developing the relevant test methods, where necessary. As a first step, a state-of-the-art report was issued by CIGRE in Technical Brochure 255. Thirteen properties were identified; standardized test methods and minimum requirements were available for eleven of them. For the remaining property of hydrophobicity retention and recovery, test methods and minimum requirements still need to be defined. This will be the future task of SC D1. This document presents, as a conclusion of the CIGRE report, the important material properties for polymeric materials used in outdoor insulation, where they are applicable, and lists standardized test methods including minimum requirements. If no standardized tests are available, then test methods reported in literature (references in the bibliography) are summarized.

SELECTION GUIDELINES FOR POLYMERIC MATERIALS FOR OUTDOOR USE UNDER HV STRESS

1 Scope

This document presents the important material properties of polymeric materials used in outdoor insulation and, where applicable, lists standardized test methods including minimum requirements. If no standardized tests are available, the test methods reported in literature are summarized.

This document is valid for insulating materials having polymeric insulation, which are used in outdoor high voltage electrical applications with a system voltage greater than 1 000 V AC and 1 500 V DC (several tests are only defined for alternating current, which are not applicable for direct current). Such applications are relevant where the housing is an integral part of the device, for example in surge arresters and cable terminations. The scope of this document is limited to the insulation materials only and is not generally intended for coating materials (coating materials are, for example, thin layers applied on toughened glass and ceramic). Some tests mentioned in this document are applicable for coating and are under consideration by CIGRE. The performance of insulators in service depends on several factors such as the type of material, the design and environmental conditions. Consequently, the choice of materials that fulfil the requirements listed in Table 1 is a necessary condition but does not guarantee satisfactory performance when used in outdoor insulation.

In Annex A and Annex B different test methods for testing additional properties are given, which are not standardized.

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 60243-1, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60243-2, *Electric strength of insulating materials – Test methods – Part 2: Additional requirements for tests using direct voltage*

IEC 60455-2, *Resin based reactive compounds used for electrical insulation – Part 2: Methods of test*

IEC 60587, *Electrical insulating materials used under severe ambient conditions – Test methods for evaluating resistance to tracking and erosion*

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

IEC 61621, *Dry, solid insulating materials – Resistance test to high-voltage, low-current arc discharges*

IEC TS 62073, *Guidance on the measurement of hydrophobicity of insulator surfaces*

IEC 62631-3-1, *Dielectric and resistive properties of solid insulating materials – Part 3-1: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity – General method*

ISO 34-1, *Rubber, vulcanized or thermoplastic – Determination of tear strength – Part 1: Trouser, angle and crescent test pieces*

ISO 483, *Plastics – Small enclosures for conditioning and testing using aqueous solutions to maintain the humidity at a constant value*

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

ISO 6721-11, *Plastics – Determination of dynamic mechanical properties – Part 11: Glass transition temperature*

ISO 11357-2, *Plastics – Differential scanning calorimetry (DSC) – Part 2: Determination of glass transition temperature and step height*

ISO 11359-2, *Plastics – Thermomechanical analysis (TMA) – Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

3 Terms and definitions

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

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

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

3.1
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 (climatic (temperature, pressure, humidity), and the method for cleaning or electrostatic charges can affect the measured degree of hydrophobicity.

3.2
hydrophobicity class
HC
specific level of the scale used in the spray method (Method C)

Note 1 to entry: Seven classes, HC1 to HC7, have been defined. HC1 corresponds to the most hydrophobic surface and HC7 to the most hydrophilic surface.

[SOURCE: IEC TS 62073:2016, 2.6]

3.3
hydrophobicity transfer
phenomenon of a transfer of hydrophobicity from the bulk of the housing material onto the pollution layer on its surface

[SOURCE: CIGRE TB 442:2010, Clause 4]

3.4
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, 3.1.4. modified – The text after "pollution" has been added and the Note to entry has been deleted.]

4 Important material properties

4.1 General

This document defines the important properties that need to be tested on the material itself in order to ensure the functioning of the material under normal operating service conditions. Physical, mechanical, electrical and chemical properties of the materials have been considered.

According to their function in the insulation, three categories of insulating materials are considered:

- housing materials (in general a silicone rubber, EPDM, EVA, etc.);
- core materials (FRP, etc.);
- structural materials (epoxy, etc.).

The minimum requirements are, as far as possible, based on the performance of polymeric insulators in service.

4.2 Resistance to tracking and erosion

The inclined-plane-test according to IEC 60587 is easily applicable, shows a good reproducibility and allows a good differentiation between insulating materials with respect to the resistance of electrical insulating materials against erosion and tracking. The thickness of the test specimens should be 6 mm ± 0,5 mm.

The minimum requirements are given in Table 1.

NOTE IEC 60587 covers only alternating current. A tracking and erosion test for direct current is still under consideration by CIGRE (see also CIGRE TB 611).

4.3 Arc resistance

The test for the arc resistance capability of housing and structural materials is carried out according to IEC 61621.

The minimum requirements are given in Table 1.

NOTE IEC 61621 covers only alternating current. An arc resistance test for direct current is still under consideration by CIGRE.

4.4 Water diffusion test (resistance of material to chemical and physical degradation by water)

4.4.1 General

The following procedure is primarily intended to evaluate the core material for resistance to water attack. It can be also used to evaluate the resistance to water attack of housing materials, if suitable.

4.4.2 Test specimens

At least six material samples are cut approximately 90° to the long axis of the insulating core with a diamond-coated circular saw blade under running cold water. The length of the samples h should be 30 mm ± 0,5 mm. The cut surfaces are smoothed by means of a fine abrasive cloth (grain size 180). The cut ends should be clean and parallel. Detailed requirements for the dimension of the specimen under test (e.g. circumstance, persistent) are defined in the related products standards.

If the samples cannot be cut from the insulator or other components, they are to be tested. Samples are prepared separately by using a similar manufacturing process and parameters as intended for the production of the insulating parts.

4.4.3 Test procedure

4.4.3.1 Pre-stressing

The surfaces of the specimens are cleaned with ethanol and filter-paper immediately before boiling. The specimens are 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 are boiled together in the same container. An example of such a container is shown in Figure 1.

After boiling, the specimens are 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 is carried out within the next 3 h after the removal of the specimens from the boiling container.