IEEE Guide for Test Methods and Procedures to Evaluate the Electrical Performance of Insulators in Freezing Conditions

IEEE Dielectrics and Electrical Insulation Society

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Approved 18 June 2009

IEEE-SA Standards Board

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Acknowledgments

Table 1 adapted and Figure B.1, Figure B.2, Figure B.3, Figure B.4 reprinted from "Insulator icing test methods and procedures—A position paper prepared by the IEEE Task Force on Insulator Icing Test Methods," 2003 [B45].

Figure 1 and Table 4 adapted from IEEE Std 4-1995.

Figure 2 reprinted from "Investigation of flashover performance of snow-covered breakers," 2007 [B73].

Figure B.5 reprinted with permission from CIGRÉ, "Influence of ice and snow on the flashover performance of outdoor insulators—Part II: Effects of snow," 2000 [B11].

Abstract: Since 1999, test methods for freezing conditions, including ice and snow, have been refined by the IEEE Dielectrics and Electrical Insulation Society and IEEE Power and Energy Society Task Forces on insulator icing. In this guide, the discussion is consolidated, and specific, appropriate, and reproducible test methods for selecting adequate insulators are recommended. Test methods for substation and line insulators at distribution and transmission voltage levels are included in the scope. Special measures to reproduce the environmental and insulator parameters that influence the risk of flashover in freezing conditions are detailed in the test methods. Statistical methods are also recommended to assist in the insulator selection process.
Keywords: cold fog, contamination, high-voltage testing, ice, icing, insulators, salt fog, snow

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Introduction

This introduction is not part of IEEE Std 1783-2009 IEEE Guide for Test Methods and Procedures to Evaluate the Electrical Performance of Insulators in Freezing Conditions.

In many cold climate regions, overhead transmission and distribution lines as well as their substation equipment are subjected to ice and snow accumulations that may be contaminated in the same ways that affect natural rain. Insulator standards presently call for a wet test at a controlled rain rate but do not recommend icing test methods. While the electrical withstand in a wet test is well above typical service voltage stress, this may not be the case in cold conditions.

Certain sequences of ice or snow accumulation and melting may cause a drastic decrease in electrical insulation strength. Especially of highly stressed, extra high-voltage and ultra high-voltage insulators, this can lead to insulator flashovers at normal service voltage and power outages. Flashover problems on ice- and snow-covered insulators have been reported in North America and many countries including China, Czech Republic, England, Finland, Japan, Norway, Switzerland, Sweden, and the former Yugoslavia.

The industry need for insulation coordination in the affected countries was a source of motivation to establish an IEEE Task Force on Insulator Icing Test Methods in 1999. In 2003, this Task Force recommended icing test methods and procedures in "Insulator icing test methods and procedures—A position paper prepared by the IEEE Task Force on Insulator Icing Test Methods," [B45].[a] Their scope covered all insulators, including ceramic and nonceramic types, because both have similar problems in the presence of ice. Test parameters were adapted from IEEE Std 4™, IEC 60060, IEC 60129, and IEC 60507 in a joint development effort with a CIGRE Ice and Snow Task Force.[b] After additional ice and snow testing experience using the Task Force recommendations led to positive industry response, it is now reasonable to formally endorse the test methods as an IEEE standard.

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1. Overview

1.1 Scope

The guide specifies procedures for testing equipment when external insulation of the test object is subjected to combinations of contamination, ice, snow, or cold fog. The methods are applicable only to tests on equipment with a rated voltage above 1 kV.

1.2 Purpose

The test methods recommended in this guide supplement the general requirements regarding equipment, objects, and procedures for standard high-voltage testing. The guide also describes some recommended methods evaluating the test results.

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2. Normative references

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Accredited Standards Committee C-2, National Electrical Safety Code® (NESC®).[1, 2]

IEC 60060-1, High-voltage test techniques—Part 1: General definitions and test requirements.[3]

IEC 60060-2, High-voltage test techniques—Part 2: Measuring systems.

IEC 60060-3, High-voltage test techniques—Part 3: Definitions and requirements for on-site testing.

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

IEC 61245, Artificial pollution tests to be used on dc systems.

IEC 61774, Overhead lines – Meteorological data for assessing climatic loads

IEEE Std 4™, IEEE Standard Technique for High-Voltage Testing.[4, 5]

IEEE Std C37.34™, IEEE Standard Test Code for High-Voltage Air Switches.

3. Definitions, acronyms, and abbreviations

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be referenced for terms not defined in this clause.[6]

3.1 Definitions

accuracy: The degree of agreement of the observed value with the conventionally true value of the quantity being measured.

applied water conductivity: The electrical conductivity of water used to simulate ice, snow, or cold fog accretion on insulators, corrected to 20 °C.

arc: A discharge of electricity through a gas, normally characterized by a voltage drop in the immediate vicinity of the cathode approximately equal to the ionization potential of the gas.

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atmospheric icing: The expression "atmospheric icing" comprises all processes where drifting or falling water droplets, rain, drizzle, or wet snow in the atmosphere freeze or stick to any object exposed to the weather.

cold fog (freezing fog): Visible aggregate of minute, supercooled water droplets suspended near the earth's surface whose droplets freeze upon contact with exposed objects and form a coating of hoarfrost and/or glaze. When composed of ice crystals, it is termed ice fog. According to international definitions, fog reduces visibility below 1 km. Fog differs from clouds only in that the base of fog is at the earth's surface while clouds are above its surface. Fog is distinguished from haze by its appreciable dampness and grey color. Mist may be considered as intermediate between fog and haze. Near industrial and heavy traffic areas, fog is often mixed with smoke and vehicle exhaust, and this combination is known as smog.

conductivity: A material property given by the conduction-current density, divided by the applied electric-field intensity. In general, it is a complex tensor quantity.

NOTE—In liquids, conductivity is often measured in units of microsiemens per centimeter (μS/cm).[7]

creepage distance: *See:* **leakage distance**.

critical flashover voltage: The amplitude voltage of a given wave shape that, under specified conditions, causes flashover through the surrounding medium on 50% of the voltage applications.

critical impulse flashover voltage (CFO): The crest value of the impulse voltage wave that, under specified conditions, causes disruptive discharge through the surrounding medium on 50% of the applications.

dew-point temperature: The temperature at which the water vapor in the gas begins to condense.

discharge: The passage of electricity through gaseous, liquid, or solid insulation that does not normally conduct electricity. Discharge is associated with nonlinear processes of avalanche ionization and development of electrically conducting plasma that may or may not be luminous.

disruptive discharge (flashover): A discharge that completely bridges the insulation under test, reducing the voltage between the electrodes to a finite value that is nearly constant for all currents and is negligible with respect to the supply voltage.

disruptive discharge probability (flashover probability): The probability that one application of a prospective voltage of a given shape and type may cause a disruptive discharge.

disruptive discharge voltage (flashover voltage): The voltage causing the disruptive discharge for tests with direct voltage, alternating voltage, and impulse voltage chopped at or after the peak; the voltage at the instant when the disruptive discharge occurs for impulses chopped on the front.

dry arc distance (strike distance): The shortest distance through the surrounding medium between terminal electrodes, or the sum of the distances between intermediate electrodes, whichever is the shorter, with the insulator mounted for dry flashover test.

drizzle: Drizzle is light precipitation consisting of liquid water drops smaller than that of rain, and generally smaller than 0.5 mm (0.02 in) in diameter. Precipitation rates due to drizzle are on the order of less than 1 mm/h at the ground.

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