

# IEEE Standard Requirements, Terminology, and Test Code for Bushings for DC Applications

Sponsor

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of the  
Power Engineering Society**

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**Abstract:** This standard applies to outdoor and indoor power apparatus dc bushings of condenser type that have basic impulse insulation levels of 110 kV and above for use as components of oil-filled converter transformers and smoothing reactors, as well as air-to-air dc bushings. This standard defines the special terms used, service conditions, rating, general requirements, electrical insulation characteristics, and test procedure for the bushings for dc application.

**Keywords:** bushings, dc application

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## Introduction

(This introduction is not part of IEEE Std C57.19.03-1996, IEEE Standard Requirements, Terminology, and Test Code for Bushings for DC Applications.)

This document is based on the standard practices for bushings applied to indoor and outdoor, oil-filled, dc power apparatus, and air-to-air, wall, and roof dc bushings. It is the result of joint efforts of professional engineers, manufacturers, and users working together under the auspices of the Institute of Electrical and Electronics Engineers (IEEE). Work on this standard was started in 1988 within the Working Group on Bushings for DC Applications of the Bushing Subcommittee of the IEEE Transformers Committee. The working group decided to address requirements for these bushings in a self-standing document because many problems specific to this type of the bushing were being experienced within the industry and other available standards on bushings were inadequate for this purpose. The main reference for the resulting document was its counterpart for ac bushings, IEEE Std C57.19.00-1991, IEEE Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings, with portions adapted from the 1984 issue of IEC Publication 137, Insulating Bushings for Alternating Voltages Above 1000 V. Requirements were also coordinated with the CIGRE Joint Working Group 12/14.10 as well as with the HVDC Converter Transformer and Smoothing Reactor Subcommittee of the IEEE Transformers Committee, which developed standards for these HVDC apparatus during the same time frame.

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# IEEE Standard Requirements, Terminology, and Test Code Bushings for DC Applications

## 1. Overview

### 1.1 Scope

This standard applies to outdoor and indoor power apparatus dc bushings of condenser type that have basic impulse insulation levels of 110 kV and above for use as components of oil-filled converter transformers and smoothing reactors, as well as air-to-air dc bushings. This standard does not apply to the following:

- a) High-voltage cable terminations (potheads)
- b) Bushings for instrument transformers
- c) Bushings for test transformers
- d) Bushings in which the internal insulation is provided by a gas
- e) Bushings applied with gaseous insulation (other than air at atmospheric pressure) external to the bushing
- f) Bushings for distribution class transformers

### 1.2 Purpose

This standard defines the special terms used, service conditions, rating, general requirements, electrical insulation characteristics, and test procedure for the bushings for dc application.

## 2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by a revision, the revision shall *not* apply.

ANSI C84.1-1982, Electric Power Systems and Equipment—Voltage Ratings (60 Hz).<sup>1</sup>

<sup>1</sup>ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

ANSI C92.2-1981, Power Systems—Preferred Voltage Ratings for Alternating-Current Electrical Systems and Equipment Operating at Voltages above 230 kV Nominal (revision and redesignation of ANSI C92.2-1987).

IEC 137 (1984), Insulating bushings for alternating voltages above 1000 V.<sup>2</sup>

IEC 270 (1981), Partial discharge measurements.

IEC 60-1 (1989), High-voltage test techniques. Part 1: General definitions and test requirements.

IEEE Std 4-1995, IEEE Standard Techniques for High-Voltage Testing (ANSI).<sup>3</sup>

IEEE Std 100-1992, IEEE Dictionary of Electrical and Electronics Terms (ANSI).

IEEE Std 1313-1993, IEEE Standard for Power Systems—Insulation Coordination (formerly C92.1) (ANSI).

IEEE Std C57.19.100-1995, IEEE Guide for Application of Power Apparatus Bushings (ANSI).

IEEE Std C57.19.00-1991, IEEE General Requirements and Test Procedures for Outdoor Apparatus Bushings (ANSI).

IEEE Std C57.19.01-1991, IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings (ANSI).

IEEE Std C57.113-1991, IEEE Guide for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors (ANSI).

### 3. Definitions

For terms not specifically defined in this standard, see IEEE Std 100-1992.<sup>4</sup>

**3.1 ambient temperature:** The temperature of the surrounding air that comes in contact with the bushing and device or equipment in which the bushing is mounted.

**3.2 arcing distance:** The shortest external tight-string distance measured over the insulating envelope between the metal parts at line potential and ground. Formerly referred to as *striking distance* or *flashover distance*.

**3.3 absorption current:** Current resulting from charge absorbed in the dielectric as a result of polarization.

**3.4 bushing:** An insulating structure, including a through conductor or providing a central passage for such a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

<sup>2</sup>IEC publications are available from IEC Sales Department, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

<sup>3</sup>IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

<sup>4</sup>Information on references can be found in clause 2.

**3.4.1 bushing condenser:** The component within a capacitive graded bushing in which the grading element is embedded in the major insulation.

**3.4.2 capacitance graded bushing:** A bushing in which metallic or non-metallic conducting layers are arranged within the insulating material for the purpose of controlling the distribution of the electric field of the bushing, both axially and radially.

**3.4.3 completely immersed bushing:** A bushing in which both ends are intended to be immersed in an insulating medium such as oil or gas.

**3.4.4 oil-impregnated paper-insulated bushing:** A bushing in which the internal insulation consists of a condenser wound from paper and subsequently impregnated with oil. The condenser is contained in an insulating envelope, the space between the condenser and the insulating envelope being filled with oil.

**3.4.5 outdoor bushing:** A bushing in which both ends are in ambient air and exposed to external atmospheric conditions.

**3.4.6 outdoor-immersed bushing:** A bushing in which one end is in ambient air and exposed to external atmospheric condition and the other end is immersed in an insulating medium such as oil or gas.

**3.4.7 outdoor-indoor bushing:** A bushing in which both ends are in ambient air but one end is intended to be exposed to external atmospheric conditions and the other end is intended not to be so exposed.

**3.4.8 sealed bushing:** An oil-filled bushing in which the oil is contained within the bushing and not allowed to mix with the oil of the apparatus on which it is used.

**3.4.9 self-filling bushing:** An oil-filled bushing in which the oil is allowed to circulate freely between the inside of the bushing and the apparatus on which it is used.

**3.4.10 tilted bushing:** A bushing intended to be mounted at an angle of 20° to 70° from the vertical.

**3.4.11 vertical bushing:** A bushing intended to be mounted vertically or at an angle not exceeding 20° from the vertical.

**3.4.12 wall (roof) bushing:** A bushing intended to be mounted on the wall (roof) of a building such as a converter valve hall.

NOTE—A wall or a roof bushing may be an outdoor, outdoor-indoor, or indoor bushing.

**3.5 bushing test tap:** A connection to one of the conducting layers of a capacitance graded bushing for measurement of partial discharge, power factor, and capacitance values.

**3.6 bushing voltage tap:** A connection to one of the conducting layers of a capacitance graded bushing providing a capacitance voltage divider.

NOTE—Additional equipment can be designed, connected to this tap, and calibrated to indicate the voltage applied to the bushing. This tap can also be used for measurement of partial discharge, power factor, and capacitance values.

**3.7 capacitance (of bushing):**

- a) The main capacitance,  $C_1$ , of a bushing is the capacitance between the high-voltage conductor and the voltage tap or the test tap.
- b) The tap capacitance,  $C_2$ , of a capacitance graded bushing is the capacitance between the voltage tap and mounting flange (ground).