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INTERNATIONAL STANDARD

Bushings for DC application

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This International Standard has been prepared by a joint working group of sub-committee 36A: Insulated bushings, of IEC technical committee 36: Insulators and Bushing subcommittee of the IEEE-PES transformer committee¹.

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

FDIS	Report on voting
36A/173/FDIS	36A/174/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 stability 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- withdrawn,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.

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¹ A list of IEEE participants can be found at the following URL:
<http://standards.ieee.org/downloads/65700/65700-19-03-2014/65700-19-03-2014_wg-participants.pdf>.

INTRODUCTION

In this first edition of IEC/IEEE 65700-19-03, service experiences as well as established market requirements have been harmonized with existing IEC and IEEE standards, primarily:

IEC 60137, *Insulated bushings for alternating voltages above 1 000 V*

IEC 62199, *Bushings for DC application*

IEEE Std C57.19.00™, *IEEE Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings*

IEEE Std C57.19.03™, *IEEE Standard Requirements, Terminology and Test Code for Bushings for DC Application*

This dual numbered standard replaces the previous IEC and IEEE DC bushing standards.

Where applicable, reference is also made to the following standards:

IEC 61462, *Composite insulators – Hollow insulators for use in outdoor and indoor electrical equipment*; and

IEC 62155, *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*.

Non-ceramic bushing insulators are widely used in DC applications and this standard applies to similar qualification procedures on all types of insulators, except for the artificial pollution test. Preparation of a bushing for an artificial pollution test destroys the surface of a composite insulator and therefore cannot be performed on such bushings.

The range of type tests and routine tests has been carefully planned, considering that high voltage direct current (HVDC) power transmission is a mature technology, but still with limited service experience compared to AC systems and voltage coordination may vary with different system HVDC design practices.

Work on IEEE Std C57.19.03 edition 1 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 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 and IEC 60137. 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.

IEEE Std C57.19.03:1996 was approved by the IEEE-SA Standards Board on 20 June 1996 and published on 6 January 1997. During the reaffirmation process for this document in 2002, several errors in the document were reported. All known errors were corrected in a corrigendum in December 2005. This revised standard includes the corrections made in the corrigendum.

Work on IEC 62199 started in 2000 by IEC SC 36A, the insulated bushings subcommittee of IEC TC 36, the insulators technical committee, and was largely based on IEEE Std C57.19.03. Edition 1 was published in 2004.

After work on the revision of IEEE Std C57.19.03 was started by IEEE it was agreed at a meeting of IEC TC36 in Sao Paulo in 2008 to approach IEEE to establish a Joint Maintenance Team under the Dual Logo Standard procedure. This was agreed and work on the new document IEC/IEEE 65700-19-03 was started in 2009.

BUSHINGS FOR DC APPLICATION

1 Scope

This International Standard applies to outdoor and indoor bushings of any voltage used on DC systems, of capacitance graded or gas insulated types 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:

- cable terminations (potheads);
- bushings for instrument transformers;
- bushings for test power supplies;
- bushings applied with gaseous insulation (other than air at atmospheric pressure) external to the bushing;
- bushings for industrial application;
- bushings for traction application;
- bushings for distribution class transformers.

This standard makes reference to IEC 60137 for general terms and conditions and defines the special terms used, operating conditions, ratings, test procedures as well as general mechanical and electrical requirements for bushings for DC application.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050, *International Electrotechnical Vocabulary (IEV)*. Available from:
<http://www.electropedia.org/>

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-5, *Insulation co-ordination – Part 5: Procedures for high-voltage direct current (HVDC) converter stations*

IEC 60076-1, *Power Transformers – Part 1: General*

IEC 60076-2, *Power Transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-7, *Power Transformers – Part 7: Loading guide for oil-immersed power transformers*

IEC 60137:2008, *Insulated bushings for alternating voltages above 1000 V*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60376, *Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulfur hexafluoride (SF6) taken from electrical equipment and specification for its re-use*

IEC 60836, *Specifications for unused silicone insulating liquids for electrotechnical purposes*

IEC 60867, *Insulating liquids - Specifications for unused liquids based on synthetic aromatic hydrocarbons*

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

IEC 61378-2, *Converter transformers – Part 2: Transformers for HVDC Applications*

IEC 61462, *Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods, acceptance criteria and design recommendations*

IEC 62155, *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*

CISPR 16-1 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*

CISPR 18-2, *Radio interference characteristics of overhead power lines and high-voltage equipment – Parts 2: Methods of measurement and procedure for determining limits*

IEEE Std C57.19.00™-2004, *IEEE General Requirements and Test Procedures for Outdoor Apparatus Bushings (ANSI)*

IEEE Standards Dictionary Online²

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60137, IEEE Std C57.19.00, IEC 60050-471 and the IEEE Standards Dictionary Online, as well as the following, apply.

3.1.1

DC bushing

bushing subject to DC voltage stress, i.e. bushings applied to the valve winding side of a converter transformer, bushings applied to a DC smoothing reactor, wall bushing or a bushing applied to a converter valve

² Subscription is available at http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html

3.1.2

bushing for pure DC application

DC bushing subject to a DC voltage with only a small AC voltage ripple, such as applied on the high voltage side of a DC converter valve

3.1.3

bushing for combined voltage application

DC bushing subject to a large AC voltage superimposed on a DC bias voltage, such as a bushing applied to the valve winding side of a converter transformer

3.1.4

wall bushing

roof bushing

bushing intended to be mounted on the wall (roof) of a building such as a converter valve hall

3.1.5

tilted bushing

bushing intended to be mounted at an angle of 20° to 70° from the vertical

3.1.6

vertical bushing

bushing intended to be mounted vertically or at an angle not exceeding 20° from the vertical

3.1.7

horizontal bushing

bushing intended to be mounted horizontally or at an angle 70° to 90° from the vertical

3.1.8

draw-lead bushing

bushing that will allow use of a draw-lead conductor

3.1.9

draw-lead conductor

cable or solid conductor that has one end connected to the transformer or reactor winding and the other end drawn through the central tube of the bushing and connected to the top of the bushing

3.1.10

major insulation

insulation material providing the dielectric, which is necessary to maintain proper isolation between the energised conductor and ground potential, consisting of internal insulation and the insulation envelope(s)

3.1.11

internal insulation

Insulating material provided in a radial direction around the energised conductor in order to insulate it from the ground potential

3.1.12

charging current

capacitive current

current resulting from charge absorbed by the capacitor formed by the capacitance of the bushing

3.1.13

dissipation factor

tangent of the dielectric loss angle

Note 1 to entry: For small values of dielectric loss, the dissipation factor is virtually equal to the insulation power factor.

3.1.14

insulation power factor

ratio of the power dissipated in the insulation, in watts, to the product of the effective voltage and current in volt-amperes, when tested under a sinusoidal voltage and prescribed conditions

Note 1 to entry: The insulation power factor is equal to the cosine of the phase angle between the voltage and the resulting current when both the voltage and current are sinusoidal.

3.1.15

partial discharge

discharge that does not completely bridge the insulation between electrodes

Note 1 to entry: The term corona is preferably reserved for partial discharge in air around a conductor, but not within the bushing assembly.

3.1.16

corona

external partial discharge due to ionisation of the air surrounding a conductor caused by a voltage gradient exceeding a critical value

3.1.17

radio-interference voltage

RIV

high-frequency voltage generated as a result of partial discharge or corona, which may be propagated by conduction, induction, radiation or a combined effect of all three

3.1.18

polarity

polarity of the DC voltage with respect to ground, for example positive or negative

3.1.19

polarity reversal

change of voltage polarity from positive to negative or from negative to positive polarity

3.1.20

insulating barriers

set of barriers which form part of the insulation structure of the converter transformer or smoothing reactor at the oil end of the DC bushing

Note 1 to entry: Usually supplied for DC systems of nominal voltage above 150 kV.

3.1.21

leakage current

conduction current

current resulting from the resistance of the dielectric insulation and surface leakage

3.2 List of variables

$I_{eq,DC}$ is the total equivalent (or test) DC current;

I_h is the magnitude of the h^{th} harmonic current in the transformer;

$I_{test,AC}$ is the applied fundamental frequency AC current during the thermal test;

R_{AC} is the resistance of the current carrying parts of the bushing under test at fundamental (or test) frequency;

R_{DC} is the DC resistance of the load current carrying part of the bushing under test;