IEC/IEEE 65700-19-03

Edition 1.0 2014-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Bushings for DC application

Traversées pour application en courant continu

IEC/IEEE 65700-19-03:2014-07(en-fr)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.080.20

ISBN 978-2-8322-6336-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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BUSHINGS FOR DC APPLICATION

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation.

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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 committee[1].

This bilingual version (2019-01) corresponds to the monolingual English version, published in 2014-07.

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.

The French version of this standard has not been voted upon.

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- withdrawn,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.

[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 Online[2]

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

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

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

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;

R_h is the AC resistance of the load current carrying part of the bushing at the h^{th} harmonic;

U_1 is the rated voltage (see 4.1.1 and 4.1.2);

U_{AC} is the AC r.m.s. test voltage for measurement of partial discharge;

U_{dm} is the highest DC voltage per valve bridge;

U_{DC} is the DC withstand test voltage;

U_{pr} is the polarity reversal test voltage (DC voltage);

U_{vm} is the maximum phase-to-phase AC operating voltage of the valve windings of the converter transformer on which the bushing will be assembled. The parameter also applies to wall bushings installed on the ac-side of the converter valve;

N is the number of six-pulse bridges in series from the neutral of the DC line to the rectifier bridge connected to the bushing when mounted on the converter transformer. The parameter also applies to wall bushings installed on the ac-side of the converter valve.

4 Ratings

4.1 Rated voltages

4.1.1 Rated continuous DC voltage

The rated continuous DC voltage is the maximum continuous DC voltage assigned to the bushing by the manufacturer for specified operating conditions.

4.1.2 Rated peak voltage

The rated peak voltage is the maximum value of the combination of DC voltage plus peak AC voltage that the bushing is required to withstand under the specified operating conditions.

4.2 Insulation levels

According to IEC 60071-5 the insulation levels for bushings used in DC applications do not generally follow the standard values of insulation level given in IEC 60071-1. The purchaser shall specify the insulation levels. The methods of calculation for test voltages are given in the relevant clauses of this standard.

4.3 Rated currents

The definition of rated current depends on the bushing application. If the bushing is one for pure DC application, the ratings are defined in 4.3.1. If the bushing is one for combined voltage application, the ratings are defined in 4.3.2.

4.3.1 Pure DC applications

4.3.1.1 Rated continuous DC current

The rated continuous DC current is the maximum continuous direct current that the bushing is required to carry under the specified operating conditions.

4.3.1.2 Rated DC overload current

The rated DC overload current is the maximum direct current that the bushing is required to carry for a stated duration of time and ambient temperature. The purchaser shall specify the current magnitude, duration and frequency of occurrence.