



IEEE

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INTERNATIONAL STANDARD

Bushings for DC application

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

BUSHINGS FOR DC APPLICATION

FOREWORD

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IEC/IEEE 65700-19-03 has been prepared by a joint working group of sub-committee 36A: Insulated bushings, of IEC technical committee 36: Insulators and Bushing, in cooperation with subcommittee of the IEEE-PES transformer committee, under the IEC/IEEE Dual Logo Agreement between IEC and IEEE. It is an International Standard.

This document is published as an IEC/IEEE Dual Logo standard.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

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

- a) 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*, and IEEE Std C57.19.00™, *IEEE Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings*;
- b) inclusion of voltage source converter (VSC) technologies

The text of this International Standard is based on the following IEC documents:

Draft	Report on voting
36A/255/FDIS	36A/260/RVD

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 International Standard is English.

This document was drafted in accordance with the rules given in the ISO/IEC Directives, Part 2, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications/.

The IEC Technical Committee and IEEE Technical Committee have 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- withdrawn, or
- revised.

INTRODUCTION

In this second 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*

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

Voltage source converter (VSC) technologies have also been included.

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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 liquid-filled converter transformers and smoothing reactors, as well as air-to-air DC bushings. It applies to both line commutated converter (LCC), as well as voltage source converter (VSC) technologies. This document 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 document refers 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 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.

NOTE For this document, bushings complying with IEC standards (IEC profile, 3.1.20) refer to IEC documents, and bushings complying with IEEE standards (IEEE profile, 3.1.21) refer to IEEE documents, unless stated otherwise. A cross-reference list is given in Annex F.

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 60071-11, *Insulation co-ordination – Part 11 : Definitions, principles and rules for HVDC system*

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 mineral-oil-immersed power transformers*

IEC 60137:2017, *Insulated bushings for alternating voltages above 1 000 V*

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

IEC 60296, *Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF₆) and complementary gases to be used in its mixtures for use in electrical equipment*

IEC 60422, *Mineral insulating oils in electrical equipment – Supervision and maintenance guidance*

IEC TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

IEC TS 60815-4, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 4: Insulators for d.c. systems*

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

IEC 61462, *Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with AC rated voltage greater than 1 000 V AC and D.C. voltage greater than 1 500 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*

IEC/IEEE 60076-57-129:2017, *Power transformers – Part 57-129: Transformers for HVDC applications*

IEEE Std 4™, *IEEE Standard Techniques for High-Voltage Testing*

IEEE Std 430™, *IEEE Standard Procedures for the Measurement of Radio Noise from Overhead Power Lines and Substations*

IEEE Std C37.123™, *IEEE Guide to Specifications for Gas-Insulated, Electric Power Substation Equipment*

IEEE Std C62.82.1™, *IEEE Standard for Insulation Coordination – Definitions, Principles, and Rules*

IEEE Std C62.82.2™, *IEEE Guide for the Application of Insulation Coordination*

IEEE Std C57.106™, *IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment*

IEEE Std C57.113™, *IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors*

IEEE Std C57.12.00™, *IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE Std C57.12.10™, *IEEE Standard Requirements for Liquid-Immersed Power Transformer*

IEEE Std C57.12.80™, *IEEE Standard Terminology for Power and Distribution Transformers*

IEEE Std C57.12.90™, *IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE Std C57.12.91™, *IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*

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

IEEE Std C57.19.01™, *IEEE Standard for Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings*

IEEE Std C57.19.100™ *IEEE Guide for Application of Power Apparatus Bushings*

IEC/IEEE 60076-57-129:2017, *Power transformers – Part 57-129: Transformers for HVDC applications*

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*

3 Terms, definitions, acronyms and variables

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60137 and IEC 60050 apply to bushing complying with IEC documents (IEC profile, 3.1.20), the terms and definitions given in IEEE C57.19.00 and the IEEE Standards Dictionary Online¹ apply to bushings complying with IEEE documents (IEEE profile, 3.1.21), and the following apply to both profiles.

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

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

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

¹ 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 applications

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

AC bushing

bushing subject to AC voltage stress with a negligible amount of DC offset, i.e. bushings applied to the valve winding side of a converter transformer in a symmetrical VSC configuration.

3.1.5

wall bushing

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

3.1.6

tilted bushing

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

3.1.7

vertical bushing

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

3.1.8

horizontal bushing

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

3.1.9

draw-lead bushing

bushing that will allow use of a draw-lead conductor

3.1.10

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

3.1.11

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

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.

3.1.13

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.

3.1.14

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.

3.1.15

corona

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

3.1.16

radio interference voltage

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

3.1.17

polarity

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

3.1.18

polarity reversal

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

3.1.19

insulating barriers

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

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

3.1.20

IEC profile

iteration of the document where the user of this document follows the IEC references

3.1.21

IEEE profile

iteration of this document where the user of this document follows the IEEE references

3.2 List of acronyms and variables

$I_{eq,DC}$	is the total equivalent (or test) DC current;
I_h	is the magnitude of the h^{th} harmonic current, including fundamental frequency, through the bushing;
$I_{test,AC}$	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;