IEC/IEEE 65700-19-03

Edition 2.0 2025-07

INTERNATIONAL STANDARD

Bushings for DC application

ICS 29.080.20

ISBN 978-2-8327-0383-0

IEC/IEEE 65700-19-03:2025-07(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue
New York, NY 10016-5997
United States of America
stds.ipr@ieee.org
www.ieee.org

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About the IEEE
IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through its highly cited publications, conferences, technology standards, and professional and educational activities.

About IEC/IEEE publications
The technical content of IEC/IEEE publications is kept under constant review by the IEC and IEEE. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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 document(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.

   IEEE Standards documents are developed within IEEE Societies and Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board. IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of IEEE and serve without compensation. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards. Use of IEEE Standards documents is wholly voluntary. *IEEE documents are made available for use subject to important notices and legal disclaimers (see* https://standards.ieee.org/ipr/disclaimers.html *for more information).*

   IEC collaborates closely with IEEE in accordance with conditions determined by agreement between the two organizations. This Dual Logo International Standard was jointly developed by the IEC and IEEE under the terms of that agreement.

2) The formal decisions of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees. The formal decisions of IEEE on technical matters, once consensus within IEEE Societies and Standards Coordinating Committees has been reached, is determined by a balanced ballot of materially interested parties who indicate interest in reviewing the proposed standard. Final approval of the IEEE standards document is given by the IEEE Standards Association (IEEE SA) Standards Board.

3) IEC/IEEE Publications have the form of recommendations for international use and are accepted by IEC National Committees/IEEE Societies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC/IEEE Publications is accurate, IEC or IEEE cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications (including IEC/IEEE Publications) transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC/IEEE Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC and IEEE do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC and IEEE are not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or IEEE or their directors, employees, servants or agents including individual experts and members of technical committees and IEC National Committees, or volunteers of IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board, for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC/IEEE Publication or any other IEC or IEEE Publications.

8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that implementation of this IEC/IEEE Publication may require use of material covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. IEC or IEEE shall not be held responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patent Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

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.

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 (SF_6) 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 Online [1] 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;