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IEEE Standard for Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings

IEEE Power and Energy Society

Sponsored by the
Transformers Committee

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USA

IEEE Std C57.19.01™-2017
(Revision of IEEE Std C57.19.01-2000)

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Approved 06 December 2017

IEEE-SA Standards Board

Abstract: Electrical, dimensional, and related requirements for power transformer and reactor bushings that have basic impulse insulation levels (BILs) of 150 kV and above are covered. Specific values for dimensional and related requirements that are to be interpreted, measured, or tested, in accordance with IEEE Std C57.19.00™, are provided.

Keywords: basic impulse insulation levels, BILs, cantilever test, capacitance, creepage distance, flashover, IEEE Std C57.19.01™, line-to-ground voltage, nominal system voltage, power factor, power reactor bushings, power transformer bushings

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3 Park Avenue, New York, NY 10016-5997, USA

PDF: ISBN 978-1-5044-4494-1 STD22881
Print: ISBN 978-1-5044-4495-8 STDPD22881

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Introduction

This introduction is not part of IEEE Std C57.19.01-2017, IEEE Standard for Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings.

The tables and other information contained in this document were originally in ANSI C76.1-1943 through ANSI C76.1-1964. In August of 1968, the ANSI C76.1 Committee decided to divide the standard into three parts. The first (ANSI C76.1) covers general requirements and test procedures, the second (ANSI C76.2) covers explicit ratings and dimensions, and the third (ANSI C76.3) covers the application guide.

ANSI C76.2-1977/IEEE Std 24-1977 incorporated changes that included the following:

a) Added dual current ratings for 115 kV to 196 kV insulation class bushings for transformers and circuit breakers

b) Added voltage class ratings for 362 kV to 800 kV with wet switching impulse test values and coordination with switching surge sparkover values of arresters

c) Added and updated acceptance limits for partial discharge, power factor, and capacitance

ANSI/IEEE Std 24-1984 incorporated revisions in Table 1 and Table 9 to make them compatible with the concept of IEEE Std 262B-1977.

IEEE Std C57.19.01-1991, sponsored by the IEEE Transformers Committee, incorporated changes to make it compatible with the new test procedures established by its companion standard, IEEE Std C57.19.00-1991. These changes included Table 9 and Table 10.

IEEE Std C57.19.01-2000, sponsored by the IEEE Transformers Committee, incorporated many major changes. These changes were the result of feedback from the Edison Electric Institute (EEI), original equipment manufacturers (OEMs), and users. The ratings were standardized in an effort to create fewer ratings and reduce the need for large inventories of spare bushings, which have accumulated from decades of special designs. Bushings in inventory incur a large tax burden from accruing bushing costs in two to five years. In addition, the requirement for bushings for application on new bulk oil circuit breakers ceased because these breakers were no longer being produced. The working group reviewed this information and agreed to revise the standard to reduce the number of ratings, promote standardization, improve bushing characteristics for new transformers, and achieve overall cost improvements. This work has resulted in the reduction of designs/ratings from 56 to 21. These changes include the following:

— *Table 1—Electrical insulation characteristics.* The number of voltage classes has been reduced from 19 to 7 to cover the 34.5 kV to 765 kV voltage range. Voltage/insulation classes, which were a part of Table 1 in IEEE Std C57.19.01-1991 but not included in Table 1 of this standard, are included in Annex A to provide information on replacement bushings. The system voltage designation has been changed to indicate nominal rating in conformance with transformer standard IEEE Std C57.12.00-1993. The BIL rating for each voltage class is based on the highest BIL specified in IEEE Std C57.12.00-1993 for the same voltage class. A BIL of 2050 kV has been adopted for 765 kV rating. A column on creepage distance has been added to provide information on values corresponding to contaminated (heavy) environments as per IEEE Std C57.19.100-1995.

— *Table 2—Dimensions for bushings up to 69 kV.* Current ratings of 400/1200 A, 2000 A, 3000 A, and 5000 A have been standardized. A current transformer pocket length of 534 mm (21 in) has been standardized for these ratings. The bottom-end length has been standardized in each voltage class. The top terminal diameters have been standardized at 1.5 in for current up to 2000 A, 2 in for 3000 A, and 4 in for 5000 A rating. The bottom terminal configuration for ratings 2000 A and above have been changed from threaded stud to two- and four-hole bladed configurations similar to those in NEMA CC1-1993. Information on transformer and circuit breaker interchangeable (TBI) and breaker ratings

have been taken out. The footnote on draw-lead application has been revised to define the current carrying limit.

— *Table 3—Dimensions for bushings above 69 kV.* Current ratings of 800/1200 A, 2000 A, and 3000 A have been standardized. A current transformer pocket length of 584 mm (23 in) has been standardized for these ratings. The bottom-end length has been standardized in each voltage class. The "D" diameter for the 196/230 kV rating has been reduced. The top terminal diameters have been standardized at 1.5 in for current up to 2000 A and 2 in for 3000 A rating. Dimensions for 500 kV and 765 kV ratings have been added. Information on TBI and breaker ratings has been taken out. The footnote on draw-lead application has been revised to define the current-carrying limit.

— *Table 4—Cantilever test requirements.* The table has been simplified and expanded to include information on bushings above 345 kV. The permanent deflection at the bottom end has been revised to reflect transformer bushings requirement. Information on TBI and breaker ratings has been taken out.

— *Table 5—Partial discharge limits.* The requirement at maximum L-G voltage has been taken out.

— *Table 6—Power factor and capacitance limits.* The limit for power factor for oil-impregnated, paper-insulated bushings has been lowered from 0.55% to 0.50%. Also, the power factor change limits for these bushings have been changed from +0.02/−0.06 to +0.02/−0.04.

— In addition, metric units have been adopted as primary units followed by inch-pound-based units in parentheses. Units/dimensions that are dependent upon inch-sized dies/tools have not been converted to metric units. Threads/inch and flange bolt hole diameters fall into this category.

— *Annex A (informative) Electrical insulation characteristics.* This annex has been added to include the insulation characteristics for ratings, which were a part of IEEE Std C57.19.01-1991 but not included in Table 1 of this standard. This information has been provided for replacement purposes only.

During the work on this revision, IEEE Std C57.19.01-2017, the effort and result of voltage class reduction in the previous version were reviewed. The feedback from the manufacturers and users showed that even though 25 kV and 115 kV bushings were removed from the previous standard, they were still the most commonly ordered or used bushings. Also, there was some confusion to the end users and the transformer manufacturers because some bushings specified by the users were not in the IEEE Std C57.19.01-2000 as they used to be. It was also brought up that using higher voltage bushings in lower voltage application, for example using 34.5 kV bushing in 25 kV application, will unnecessarily increase the cost of transformer due to the larger dimensions required and could also prohibit shipping transformer with bushings pre-installed on the transformer due to the transportation limitations. Therefore, it was decided to add back most of the voltage classes from the 1991 versions. Also, some additional dimensions were added.

The major changes in this revision as compared with the previous version, IEEE Std C57.19.01-2000, are listed as follows:

— *Title of the Standard*. It was decided to change the title from "Performance Characteristics and Dimensions for Outdoor Apparatus Bushings" to "Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings" to reflect the fact that the bushings are mainly used for power transformers and reactors and the oil circuit breakers, one apparatus addressed in the previous versions, are phasing out. The wording in the content of the standard has also been updated accordingly.

— *Scope*. The BIL rating was changed from "200 kV and above" to "150 kV and above". The words "in free air" has been added to distinguish this standard from IEEE Std C57.19.04, which is for the bushings used in an enclosed bus duct. The words "oil-filled transformers and reactors" have been changed to "liquid-immersed transfomers and reactors" to reflect the industry practice of using different types of insulating liquids inside the transformers and reactors. The last sentence "For information on ratings not covered by this standard and for replacement bushings for oil circuit breakers, refer to IEEE Std C57.19.01-1991" has been removed to reflect the title change.

— *Table 1, Electrical insulation characteristics for power transformer and reactor bushings (nominal system voltage through 765 kV)*. The BIL ratings of 150 kV, 250 kV, 550 kV, and 750 kV have been added. It was also decided to adopt the rated maximum line-to-ground voltages from 1991 version so the maximum line-to-ground voltages of 88 kV, 102 kV, and 146 kV are used for the bushings with BIL ratings of 550 kV, 650 kV, and 750 kV, respectively.

— *Table 2, Dimensions of power transformer and reactor bushings (nominal system voltage through 69 kV)*. The table includes the dimensions for the newly-added bushings. It was decided to list four current ratings for each system voltage, i.e., 400/1200 A, 2000 A, 3000 A, and 5000 A. If the required ratings are not among the four ratings listed, the users may either choose higher rating bushings or make an agreeement with the bushing supplier.

— *Table 3, Dimensions of power transformer and reactor bushings (nominal system voltage above 69 kV)*. The table includes the dimensions for the newly-added bushings. It was decided to list four current ratings (800/1200 A, 2000 A, 3000 A, and 5000 A) for up to 230 kV bushings and the dimensions are provided accordingly. If the required ratings are not among the four ratings listed, the users may either choose higher rating bushings or make an agreeement with the bushing supplier.

— *Table 4, Cantilever design test requirements for outdoor power transformer and reactor bushings*. The nominal system voltages were updated to reflect the aforementioned changes.

— *Table 5, Partial discharge limits*. Note *d*, for the solid bushings, has been extended to clearly state that the testing duration is to get a stable partial discharge reading rather than one hour . The reason is that the solid bushings are tested at 2 times maximum line-to-ground voltage for partial discharge while other bushings are tested at 1.5 times.

— *Annex A Transformer-Breaker-Interchangeable (TBI) bushings.* The original "Table A.1, Electrical insulation characteristics for outdoor apparatus bushings (nominal system voltage 15–800 kV) (for replacement purposes only)" has been removed since the major missing voltage levels have been added back to the main content of the standard. A new "Table A.1, TBI bushing cantilever test requirements" was added for informative purpose so the definition of the widely used term Transformer-Breaker-Interchangeable (TBI) is kept.

Contents

IEEE Standard for Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings

1. Scope

This standard covers electrical, dimensional, and related requirements for outdoor power apparatus bushings that have basic impulse insulation levels (BILs) of 150 kV and above. It provides specific values for dimensional and related requirements that are to be interpreted, measured, or tested in accordance with IEEE Std C57.19.00™.[1] Bushings covered by this standard are intended for use in free air as components of liquid-immersed transformers and reactors.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std C57.12.00™, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.[2,3]

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

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

3. General requirements

Refer to IEEE Std C57.19.00 for general requirements, definitions, and methods of measurements or tests applying to detailed requirements given in Clause 4.

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