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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

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

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

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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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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 forApplication of PowerApparatus 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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4. Detailed requirements

Power transformer and reactor bushings conforming to this standard shall meet the requirements of the following as applicable:

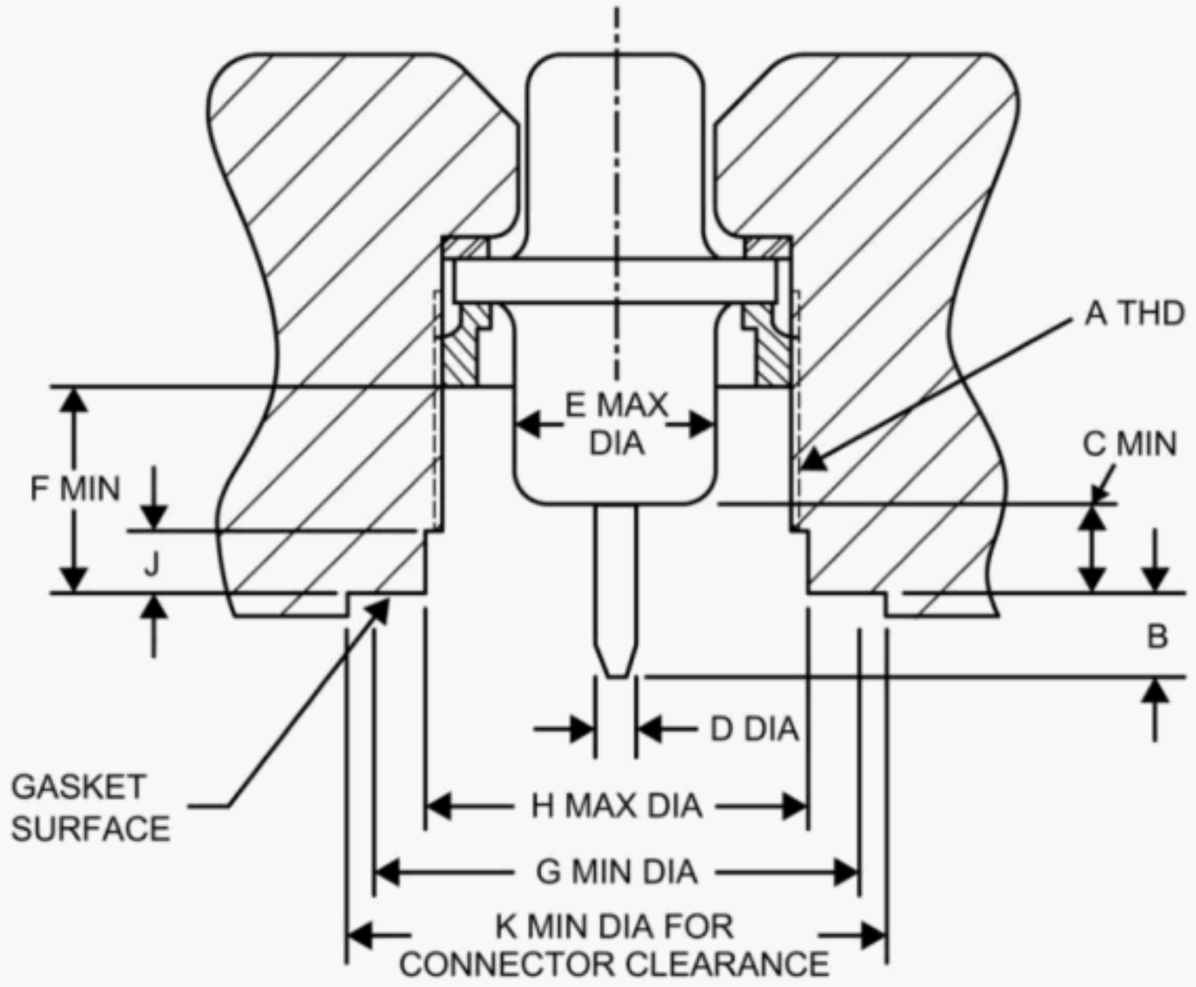
a) Electrical insulation characteristics of Table 1[4]

b) Dimensions of Figure 1, Figure 2, Figure 3, Table 2, and Table 3

c) Cantilever test values of Table 4

d) Partial discharge limits of Table 5

e) Power factor and capacitance limits of Table 6

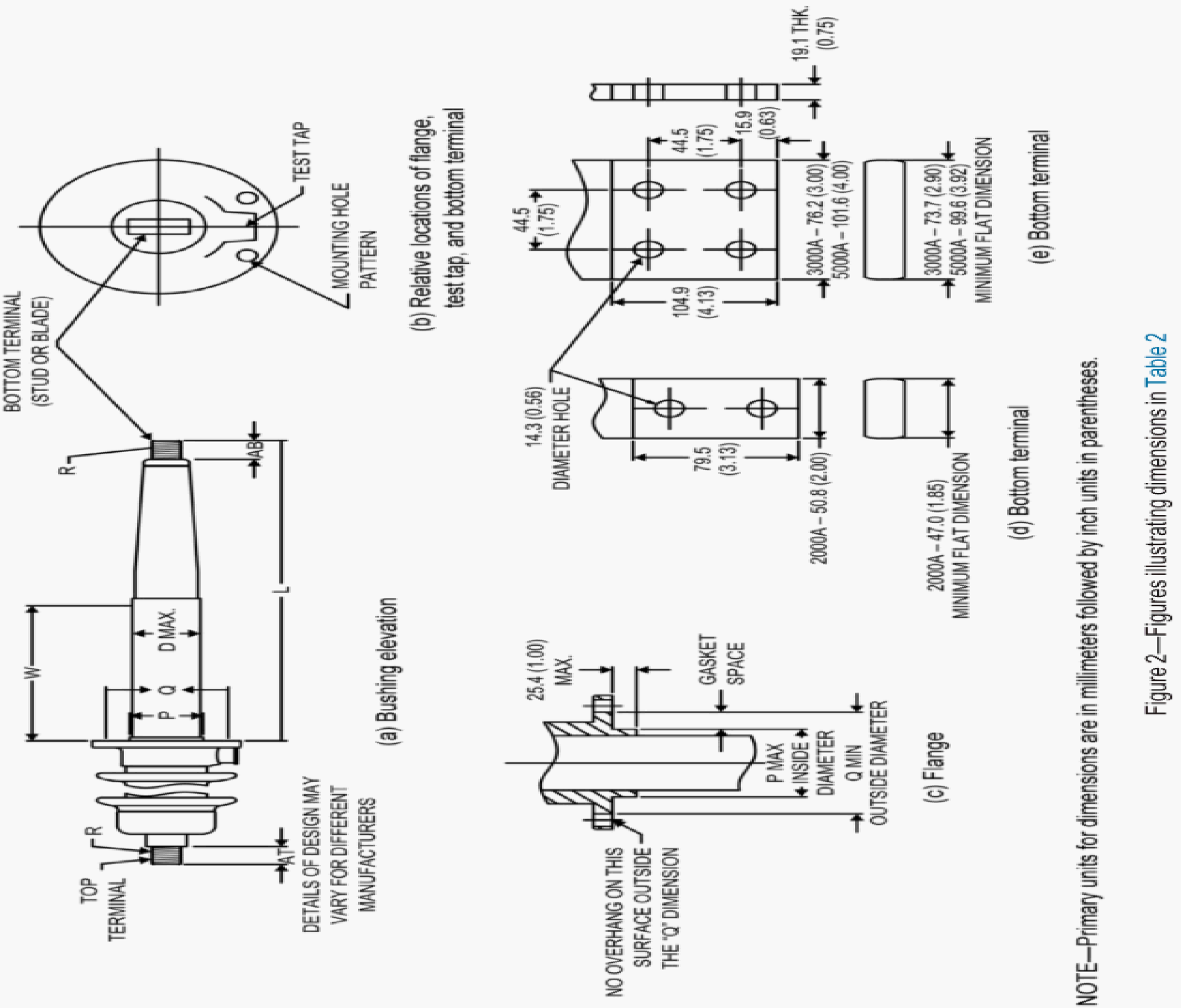


A. (2.25-12 UNF 2B)
B. 9.53 MIN – 19.05 MAX (0.375 MIN – 0.750 MAX)
C. 7.87 (0.310)
D. 7.95 ± 0.08 (0.313 ± 0.003)
E. 44.45 (1.75)
F. 25.4 (1.0)
G. 74.68 (2.94)
H. 57.56 ± 0.08 (2.266 ± 0.003)
J. 3.18 MIN – 7.37 MAX (0.125 MIN – 0.290 MAX)
K. 76.96 (3.030)

NOTE—Primary units for dimensions are in millimeters followed by inch units in parentheses.

Figure 1—Bushing voltage tap dimensions, Type A: Normally grounded

[4]Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.



NOTE—Primary units for dimensions are in millimeters followed by inch units in parentheses.

Figure 2—Figures illustrating dimensions in Table 2

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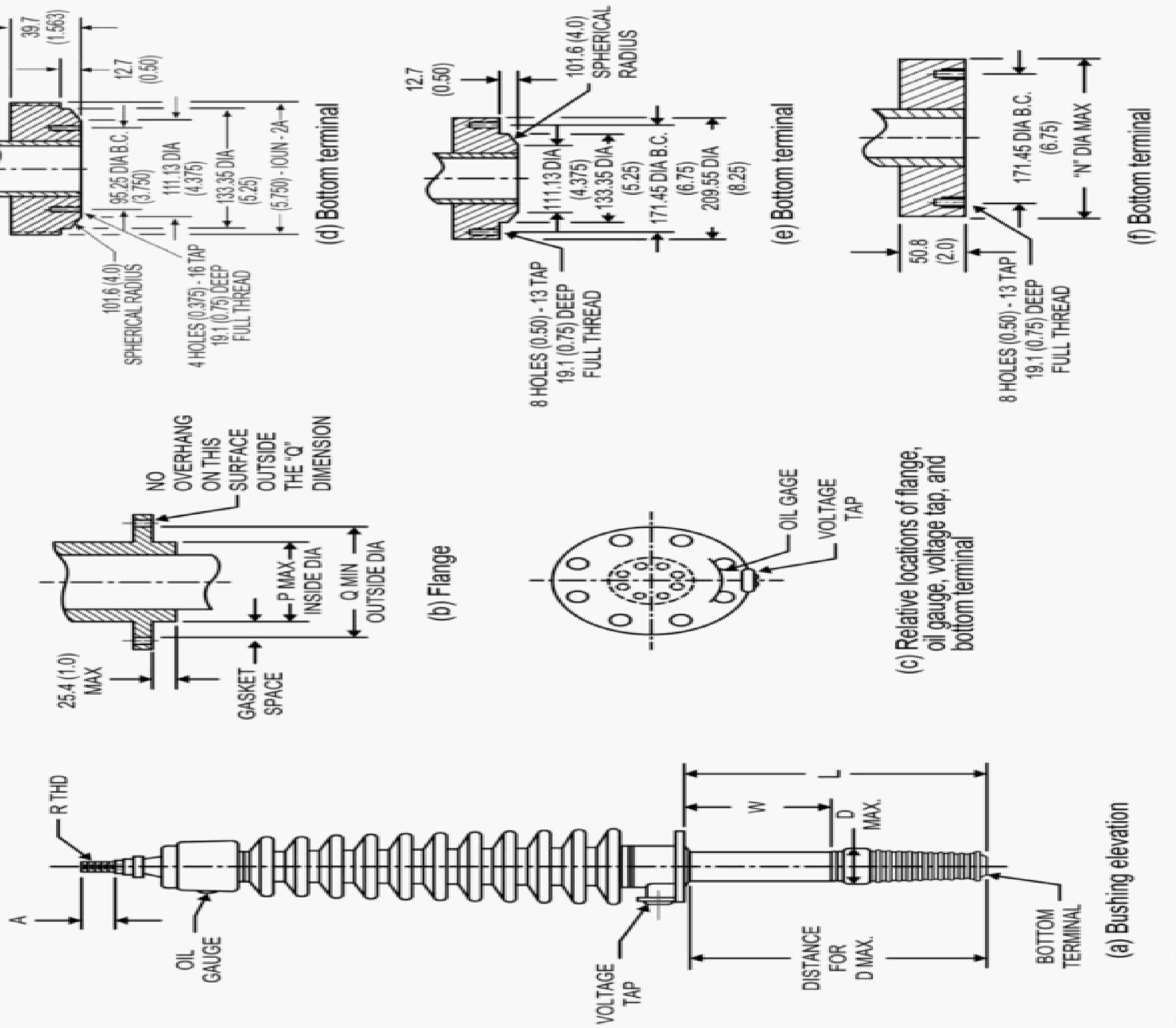

NOTE—Primary units for dimensions are in millimeters followed by inch units in parentheses.

Figure 3—Figures illustration dimensions in Table 3

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Table 1—Electrical insulation characteristics for power transformer and reactor bushings (nominal system voltage through 765 kV)

Basic lightning impulse insulation level (BIL) (kV)	Nominal system voltage (see Note 1) (kV)	Rated maximum line-to-ground voltage (kV)	Creepage distance, light contamination Minimum (see Note 2)		Creepage distance, heavy contamination Minimum (see Note 2)		Withstand tests				
							60 Hz Lightning impulse				
			(mm)[a]	(in)	(mm)[a]	(in)		Full wave (kV)	Chopped wave crest, minimum time to flashover 3 µs (kV)		
							1 min dry rms (kV)				
								10 s wet rms (kV)			
											Wet switching impulse (kV)[b]
Col. 1	Col. 2	Col. 3	Col. 4		Col. 5		Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
150	25	16	405	16	635	25	60	50	150	175	—
200	34.5	22	560	22	880	35	80	75	200	230	—
250	46	29	735	29	1 170	46	105	95	250	290	—
350	69	44	1 115	44	1 755	69	160	140	350	402	—
550	115	88	1 855	73	2 920	115	260	230	550	632	—
650	138	102	2 235	88	3 510	138	310	275	650	750	—
750	161	146	2 590	102	4 090	161	365	315	750	865	—
900	230	146	3 720	146	5 845	230	425	350	900	1 040	—
1 175	345	220	5 580	220	8 765	345	520	—	1 175	1 350	825
1 675	500	318	8 085	318	12705	500	750	—	1 675	1 925	1 175
2 050	765	485	12370	487	19435	765	920	—	2 050	2 360	1 450

NOTE 1—The voltage levels in Col. 2 were selected from the dielectric insulation level tables of IEEE Std C57.12.00.

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NOTE 2—The millimeter creepage values in Col. 4 and Col. 5 are based on 28 mm/kV (light) and 44 mm/kV (heavy) of nominal line-to-ground voltage as per IEEE Std C57.19.100. Nominal line-to-ground voltage is nominal system voltage (Col. 2) divided by 1.732. For other creepage values, refer to IEEE Std C57.19.100.

[a]Primary units for dimensions are in millimeters.

[b]Dry negative switching impulse withstand voltage of the bushing must be at least equal to the switching impulse withstand voltage for the corresponding BIL specified in IEEE Std C57.12.00.

Table 2—Dimensions of power transformer and reactor bushings (nominal system voltage through 69 kV)

Rating				Bottom end						Tube	Top terminal						Flange gasket space		Flange bolting details		
Nominal system voltage (kV) (BIL) (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in)	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Lower terminal details or usable thread Min. [mm (in)]	Thread class UNF-2A	Usable thread Min. [mm (in)]	Thread class UNF-2A Max. [mm (in)]	Inside diameter [mm (in)]	Outside diameter [mm (in)]	Hole size No. of bolts	Bolt circle diameter [mm (in)]							
Col. 1	Col. 2	Col. 3		Col. 4		Col. 5	Col. 6				Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15	Col. 16		
		[mm (in)]		L[c]	W[c]	D[c]					AB[c]	R[c]	AT[c]	R[c]	P[c]	Q[c]					
25 150	400[a]/1200 749 (29.50)	534 (21.00)	79 (3.13)	— (0.88)	54 (2.13)	— (1.5- 12)	54 (2.13)	— (1.5- 12)	102 (4.00) 4	159 (6.25)	— (0.88)	184.2 (7.25)									
2000[b] 800	534 (21.00)	92 (3.63)	64 (2.50)	— (1.5-	102 (4.00)	159 (6.25)	— (0.88)	184.2 (7.25)													
(31.50)		Figure 2(d)			12)			4													
3000[b] 800	534 (21.00)	—																			
(31.50)		114 (4.50)	76 (3.00)	— (2.0-	140 (5.50)	184 (7.25)	— (0.88)	209.6 (8.25)													
		Figure 2(e)		12)		4															
5000[b] 838	534 (21.00)	—																			
(33.00)		191 (7.50)	102 (4.00)	— (4.0-	191 (7.50)	235 (9.25)	— (0.88)	260 (10.25)													
		Figure 2(e)		12)		6															
34.5 200	400[a]/1200 800	534 (21.00)	89 (3.50)	— (0.88)	54 (2.13)	— (1.5- 12)	54 (2.13)	— (1.5- 12)	102 (4.00) 4	159 (6.25)	— (0.88)	184.2 (7.25)									
(31.50)																					
2000[b] 851	534 (21.00)	102 (4.00)	64 (2.50)	— (1.5-	102 (4.00)	159 (6.25)	— (0.88)	184.2 (7.25)													
(33.50)		—		12)		4															
		Figure 2(d)																			

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										—
3000[b] 851 (33.50)	534 (21.00)	127 (5.00)	76 (3.00)	—	(2.0–12)	159 (6.25)	210 (8.25)	—	(0.88)	235.0 (9.25)
										—
5000[b] 851 (33.50)	534 (21.00)	191 (7.50)	102 (4.00)	—	(4.0–12)	191 (7.50)	235 (9.25)	—	(0.88)	260 (10.25)
										—

Figure 2(e)

Figure 2(e)

Table continues

Table 2—Dimensions of power transformer and reactor bushings (nominal system voltage through 69 kV) (continued)

Rating				Bottom end				Tube		Bottom terminal			Top terminal			Flange gasket space		Flange bolting details		
Nominal system voltage (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in) [mm (in)]	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the flange to lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Lower terminal details or usable thread Min. [mm (in)]	Thread class UNF-2A	Usable thread Min. [mm (in)]	Thread class UNF-2A	Inside diameter Max. [mm (in)]	Outside diameter Min. [mm (in)]	No. of bolts	Hole size (in)	Bolt circle diameter [mm (in)]					
				L[c]	W[c]	D[c]					AB[c]	R[c]	AT[c]	R[c]	P[c]	Q[c]				
Col. 1	Col. 2	Col. 3		Col. 4	Col. 5	Col. 6	Col. 7	Col. 8		Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15	Col. 16			
46 250	400[a]/1200 851 (33.50)	534 (21.00)	102 (4.00)	— (0.88)	54 (2.13)	— (1.5–12)	54 (2.13)	— (1.5–12)	127 (5.00)	184 (7.25) 4	— (0.88)	209.6 (8.25)								
2000[b] 902 (35.50)	534 (21.00)	127 (5.00) — Figure 2(d) —	64 (2.50)	— (1.5–12)	140 (5.50)	184 (7.25) 4	— (0.88)	209.6 (8.25)												
3000[b] 902 (35.50)	534 (21.00)	152 (6.00) — Figure 2(e) —	76 (3.00)	— (2.0–12)	165 (6.50)	210 (8.25) 6	— (0.88)	235.0 (9.25)												
5000[b] 940 (37.00)	534 (21.00)	219 (8.63) — Figure 2(e) —	102 (4.00)	— (4.0–12)	248 (9.75)	254 (10.00) 6	— (1.25)	285.8 (11.25)												

Table continues

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Table 2—Dimensions of power transformer and reactor bushings (nominal system voltage through 69 kV) (continued)

Rating				Bottom end				Tube		Bottom terminal			Top terminal			Flange gasket space		Flange bolting details		
Nominal system voltage (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in) [mm (in)]	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the flange to lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Lower terminal details or usable thread Min. [mm (in)]	Thread class UNF-2A	Usable thread Min. [mm (in)]	Thread class UNF-2A	Inside diameter Max. [mm (in)]	Outside diameter Min. [mm (in)]	No. of bolts	Hole size (in)	Bolt circle diameter [mm (in)]					
				L[c]	W[c]	D[c]					AB[c]	R[c]	AT[c]	R[c]	P[c]	Q[c]				
Col. 1	Col. 2	Col. 3		Col. 4	Col. 5	Col. 6		Col. 7	Col. 8		Col. 9	Col. 10	Col. 11		Col. 12	Col. 13	Col. 14	Col. 15	Col. 16	
69 350	400[b]/1200 952 (37.50)	534 (21.00)	134 (5.25)	— (0.88)	54 (2.13)	— (1.5–12)	54 (2.13)	— (1.5–12)	152 (6.00)	210 (8.25) 6	— (0.88)	235.0 (9.25)								
2000[b] 1003 (39.50)	534 (21.00)	140 (5.50)	64 (2.50)	— (1.5–12)	152 (6.00)	210 (8.25) 6	— (0.88)	235.0 (9.25)												
		— Figure 2(d) —																		
3000[b] 1003 (39.50)	534 (21.00)	165 (6.50)	76 (3.00)	— (2.0–12)	178 (7.00)	235 (9.25) 6	— (0.88)	260.4 (10.25)												
		— Figure 2(e) —																		
5000[b] 1003 (39.50)	534 (21.00)	241 (9.50)	102 (4.00)	— (4.0–12)	254 (10.00)	324 (12.75) 6	— (1.25)	362.0 (14.25)												
		— Figure 2(e) —																		

NOTE 1—The "oil end" in Col. 4 and "oil level" in Col. 5 may be changed to "liquid end" and "liquid level", respectively, to reflect the scope change of "oil-immersed transformer" to "liquid-immersed transformer". However, it is not mandatary as the majority of the transformers are still filled with regular transformer oil.

NOTE 2—When furnished, the oil gage and the test tap should be in line and midway between the adjacent flange mounting bolt holes in Col. 14 to 16

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[a]For draw-lead application, the continuous-current rating of the bushing is limited to the rating stated on the bushing nameplate.This bushing can be converted from draw-lead to bottom- end application with 1200 A rating.

[b]Not designed for use with draw lead.

[c]Letters shown in dimension column heading refer to the letters in Figure 2(a) through Figure 2(e).

Table 3—Dimensions of power transformer and reactor bushings (nominal system voltage above 69 kV)

Rating			Bottom end				Tube	Bottom terminal			Top terminal			Gasket space		Flange bolting details		
Nominal system voltage (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in) [mm (in)]	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the flange to lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Terminal details	Washer diameter Max. [mm (in)]	Usable thread Min. [mm (in)]	Thread class UNF-2A	Inside diameter Max. [mm (in)]	Outside diameter Min. [mm (in)]	No. of bolts	Hole size (in)	Bolt circle diameter [mm (in)]			
			L[b]	W[b]	D[b]						N[b]	A[b]	R[b]	P[b]	Q[b]			
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15	Col. 16			
115 550 800[a]/1200 1092 (43.00)	584 (23.00)	222 (8.75)	— (1.63) Figure 3(d) —	51 (2.00)	— (1.5–12)	251 (9.88)	302 (11.88) 6	— (1.25)	337 (13.25)									
2000[c] 1092 (43.00)	584 (23.00)	222 (8.75)	64 (2.50) — Figure 3(e) —	—	251 (9.88)	302 (11.88) 6	— (1.25)	337 (13.25)										
3000[c] 1092 (43.00)	584 (23.00)	222 (8.75)	76 (3.00) — Figure 3(e) —	—	251 (9.88)	302 (11.88) 6	— (1.25)	337 (13.25)										
5000[c] 1092 (43.00)	584 (23.00)	222 (8.75)	102 (4.00) — Figure 3(e) —	—	251 (9.88)	302 (11.88) 6	— (1.25)	337 (13.25)										
138 650 800[a]/1200 1188	584 (23.00)	248 (9.75)	— (1.63) Figure 3(d) —	51 (2.00)	— (1.5–12)	276 (10.88)	327 (12.88) 6	— (1.25)	362 (14.25)									

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(46.75)									
2000[c] 1188 (46.75)	584 (23.00)	248 (9.75)	64 (2.50)	— (1.5–12)	276 (10.88)	327 (12.88)	— (1.25)	362 (14.25)	— Figure 3(e) —
3000[c] 1188 (46.75)	584 (23.00)	248 (9.75)	76 (3.00)	— (2.0–12)	276 (10.88)	327 (12.88)	— (1.25)	362 (14.25)	— Figure 3(e) —
5000[c] 1118 (46.75)	584 (23.00)	248 (9.75)	102 (4.00)	— (4.0–12)	276 (10.88)	327 (12.88)	— (1.25)	362 (14.25)	— Figure 3(e) —

Table continues

Table 3—Dimensions of power transformer and reactor bushings (nominal system voltage above 69 kV) (continued)

Rating			Bottom end				Tube	Bottom terminal		Top terminal			Gasket space		Flange bolting details		
Nominal system voltage (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in) [mm (in)]	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the flange to lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Terminal details	Washer diameter Max. [mm (in)]	Usable thread Min. [mm (in)]	Thread class UNF-2A	Inside diameter Max. [mm (in)]	Outside diameter Min. [mm (in)]	No. of bolts	Hole size (in)	Bolt circle diameter [mm (in)]		
				L[b]	W[b]	D[b]					N[b]	A[b]	R[b]	P[b]	Q[b]		
Col. 1	Col. 2	Col. 3		Col. 4	Col. 5	Col. 6	Col. 7	Col. 8			Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15	Col. 16
161 750 800[a]/1200 1276	584 (23.00)	305 (12.00)	— (1.63) Figure 3(d) —	51 (2.00)	— (1.5–12)	314 (12.38)	365 (14.38)	— (1.25) 8	400 (15.75)								
(50.25) 2000[c]	584	305	64	—	314	365	—	400									
1276 (50.25)	584 (23.00)	305 (12.00)	64 (2.50) —	—	314 (12.38)	365 (14.38)	—	400 (15.75)									
3000[c] 1276 (50.25)	584 (23.00)	305 (12.00)	76 (3.00) —	—	314 (12.38)	365 (14.38)	—	400 (15.75)									
5000[c] 1276 (50.25)	584 (23.00)	305 (12.00)	102 (4.00) —	—	314 (12.38)	365 (14.38)	—	400 (15.75)									
230 900 800[a]/1200 1276	584 (23.00)	305 (12.00)	— (1.63) Figure 3(e) —	51 (2.00)	— (1.5–12)	435 (17.13)	495 (19.50)	— (1.25) 12	533.4 (21.00)								

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(50.25)									
2000[c] 1276 (50.25)	584 (23.00)	305 (12.00)	64 (2.50)	— (1.5–12)	435 (17.13)	495 (19.50)	— (1.25)	533.4 (21.00)	
	—	Figure 3(e)	—			12			
3000[c] 1276 (50.25)	584 (23.00)	305 (12.00)	76 (3.00)	— (2.0–12)	435 (17.13)	495 (19.50)	— (1.25)	533.4 (21.00)	
	—	Figure 3(e)	—			12			
5000[c] 1276 (50.25)	584 (23.00)	305 (12.00)	102 (4.00)	— (4.0–12)	435 (17.13)	495 (19.50)	— (1.25)	533.4 (21.00)	
	—	Figure 3(e)	—			12			

Table continues

Table 3—Dimensions of power transformer and reactor bushings (nominal system voltage above 69 kV) (continued)

Rating				Bottom end				Tube	Bottom terminal		Top terminal			Gasket space		Flange bolting details		
Nominal system voltage (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in) [mm (in)]	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the flange to lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Terminal details	Washer diameter Max. [mm (in)]	Usable thread Min. [mm (in)]	Thread class UNF-2A	Inside diameter Max. [mm (in)]	Outside diameter Min. [mm (in)]	No. of bolts	Hole size (in)	Bolt circle diameter [mm (in)]			
				L[b]	W[b]	D[b]						N[b]	A[b]	R[b]	P[b]	Q[b]		
Col. 1	Col. 2	Col. 3		Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9		Col. 10	Col. 11		Col. 12		Col. 13	Col. 14	Col. 15	Col. 16
345 1175 800[a]/1200 1295	584 (23.00)	400 (15.75)	— (2.00) Figure 3(f)	210 (8.25)	51 (2.00)	— (1.5–12)	435 (17.13)	495 (19.50) 12	— (1.25)	533.4 (21.00)									
(51.00) 2000[c] 1295 (51.00)	584 (23.00)	400 (15.75) —	210 (8.25) Figure 3(f)	64 (2.50)	— (1.5–12)	435 (17.13)	495 (19.50) 12	— (1.25)	533.4 (21.00)										
3000[c] 1295 (51.00)	584 (23.00)	400 (15.75) —	210 (8.25) Figure 3(f)	76 (3.00)	— (2.0–12)	435 (17.13)	495 (19.50) 12	— (1.25)	533.4 (21.00)										
500 1675 800[a]/1200 1651	584 (23.00)	508 (20.00)	— (2.00) Figure 3(f)	305 (12.00)	51 (2.00)	— (1.5–12)	533 (21.00)	584 (23.00) 12	— (1.25)	635 (25.00)									
(65.00) 2000[c] 1651 (65.00)	584 (23.00)	508 (20.00) —	305 (12.00) Figure 3(f)	64 (2.50)	— (1.5–12)	533 (21.00)	584 (23.00) 12	— (1.25)	635 (25.00)										
3000[c] 1651	584 (23.00)	508 (20.00)	305 (12.00)	76 (3.00)	— (2.0–	533 (21.00)	584 (23.00)	— (1.25)	635 (25.00)										

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(65.00)	— Figure 3(f)	12)	12

Table continues

Table 3—Dimensions of power transformer and reactor bushings (nominal system voltage above 69 kV) (continued)

Rating				Bottom end				Tube	Bottom terminal			Top terminal			Gasket space		Flange bolting details		
Nominal system voltage (kV)	Basic lightning impulse insulation level (BIL) (kV)	Rated continuous current (A)	Oil end length ±3 mm (±0.13 in) [mm (in)]	Current transformer pocket length and distance from flange mounting surface to minimum oil level [mm (in)]	Diameter from 25.4 mm (1 in) below the flange to lower end of bushing Max. [mm (in)]	Inside tube diameter Min. (in)	Terminal details	Washer diameter Max. [mm (in)]	Usable thread Min. [mm (in)]	Thread class UNF-2A	Inside diameter Max. [mm (in)]	Outside diameter Min. [mm (in)]	No. of bolts	Hole size (in)	Bolt circle diameter [mm (in)]				
				L[b]	W[b]	D[b]					N[b]	A[b]	R[b]		P[b]	Q[b]			
Col. 1	Col. 2	Col. 3		Col. 4	Col. 5	Col. 6	Col. 7	Col. 8			Col. 9	Col. 10	Col. 11		Col. 12		Col. 13	Col. 14	Col. 15	Col. 16
765 2050	584 (23.00)	749 (29.50)	— (2.00)	330 (13.00)	51 (2.00)	— (1.5–12)	749 (29.50)	854 (33(f)3)	— (1.25)	889 (35.00)									
800[a]/1200 2159 (85.00)		Figure 3(f)																	
2000[c] 2159 (85.00)	584 (23.00)	749 (29.50) — Figure 3(f)	330 (13.00)	64 (2.50)	— (1.5–12)	749 (29.50)	854 (33.63) 16	— (1.25)	889 (35.00)										

NOTE 1—With the addition of external shield, the "L" dimension may increase.

NOTE 2—The "oil end" in Col. 4 and "oil level" in Col. 5 may be changed to "liquid end" and "liquid level", respectively, to reflect the scope change of "oil-immersed transformer" to "liquid-immersed transformer". However, it is not mandatary as the majority of the transformers are still filled with regular transformer oil.

NOTE 3—When furnished, the oil gage and the voltage tap should be in line and midway between the adjacent flange mounting bolt holes and between the adjacent bottom terminal tapped holes in Col. 14 to Col. 16.

[a]For draw-lead application, the continuous-current rating of the bushing is limited to the rating stated on the bushing nameplate. This bushing can be converted from draw-lead to bottom- end application with 1200 A rating.
[b]Letters shown in dimension column heading refer to the letters in Figure 3(a) through Figure 3(f).
[c]Not designed for use with draw lead.

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Table 4—Cantilever design test requirements for power transformer and reactor bushings

Rating		Transverse static force top and bottom[a]	
Nominal system voltage (kV)	Rated continuous current (A)	(N)	(lbf)
Col. 1	Col. 2	Col. 3	Col. 4
25–69	Up to 2000	890	200
	3000	1300	300
	5000	2200	500
115–138	All	3100	700
161 and above	All	4000	900

[a]The permanent deflection measured at the bottom end 1 min after the removal of the force shall not exceed 1.52 mm (0.060 in).

During the cantilever test, no test is required for the bottom end for draw-lead only bushings. The values in Table 4 apply to bushings operated at inclinations up to 20° from the vertical. For angles greater than 20°, an equivalent force appearing at the top terminal due to the weight of the bushing should be added to the above values when testing the bushing in the vertical position.Also, the values in Table 4 are design test requirements only and are not associated with permissible loads that can be applied to the top terminal during service. Refer to IEEE Std C57.19.100 for additional information.

Table 5—Partial discharge limits for new bushings[a]

Type of construction[b]	At 1.5 times maximum L-G voltage[c] (pC or μV)
Oil-impregnated, paper-insulated	10 [c]
Resin-impregnated, paper-insulated	10 [c]
Resin-bonded, paper-insulated	100 [c]
Cast insulation	25 [c]
Solid	50 [d]

[a]These limits include background corona. Since these measurements are related to partial discharges within the major insulation, external shielding may be used to reduce corona that may occur at the bushings terminals or the grounded projections.

[b]Refer to IEEE Std C57.19.00 for definitions of the types of constructions. For application to power transformers that require partial discharge at 1.5 times maximum L-G voltage, bushings may be selected from appropriate types of constructions.

[c]Thedurationof1.5timesmaximumL-Gvoltageinthedesigntestis1h.Duringthistest,thepartialdischargemeasurements shall be made at 5 min intervals. For the routine test, the same voltage shall be applied for a period long enough to make a stable partial discharge reading.

[d]Measured at 2 times maximum L-G voltage for a period long enough to make a stable partial discharge reading.

Table 6—C1 or C power factor and capacitance limits for new bushings

Type of construction	C1 or C power factor and capacitance		
	Power factor[a]		Capacitance
	Limit (%)	Acceptable change [b]	Acceptable change (%)[c]
Col. 1	Col. 2	Col. 3	Col. 4
Oil-impregnated, paper-insulated	0.50	+0.02/–0.04	±1.0
Resin-impregnated, paper-insulated	0.85	±0.04	±1.0
Resin-bonded, paper-insulated	2.00	±0.08	±1.0
Cast insulation	1.00	±0.04	±1.0
Solid	N/A[d]	—	—

[a] Corrected to 20°C.

[b] The algebraic difference in power factor (expressed in percent) measured at 10 kV or at the rated maximum L-G voltage before and after the dielectric withstand voltage test must be within the specified limits. For example, if the power factor of the oil-impregnated, paper-insulated bushing was 0.30% before the withstand test, the maximum acceptable power factor after the test would be 0.32%.

[c] The percent change in capacitance after the dielectric withstand test based on the initial value must be within the specified limits. The measurements are to be made at 10 kV or at rated maximum L-G voltage.

[d] There is no power factor limit for solid bushings, since the effect of stray capacitance and/or surface dielectric loss for low capacitance specimens (<100 pF) such as these can cause significant variations in the measured power factor. Tests on such bushings are usually rated on the basis of comparison of capacitance and ac dielectric loss between similar bushings, when tested at the same time and under similar conditions.

Annex A

(informative)

Transformer-Breaker-Interchangeable (TBI) bushings

Table A.1 provides the cantilever requirements published in the 1991 version of this standard for circuit breaker, transformer, and interchangeable (TBI) bushings. This data was removed from the current standard as it no longer includes circuit breaker bushings, but it is included here for historical reasons. Table 4 is to be followed for all transformer applications regardless of whether the bushing is draw lead or bottom connected. It is noted that bushings meeting or exceeding the tests in this table are not necessarily applicable to circuit breakers as some other tests may also be needed.

Table A.1—TBI bushing cantilever test requirements

Nominal system voltage	Rated continuous current		Design test [a]			
			Top transverse force static values		Bottom transverse force static values [b]	
(kV)	(A)		(N)	(lbf)	(N)	(lbf)
25	400	Transformer	668	150	—	—
	1200	Transformer	668	150	1336	300
	1200	Interchangeable	1336	300	2672	600
	2000	Circuit breaker	1781	400	3563	800
	3000	Circuit breaker	2227	500	4454	1000
	4000	Circuit breaker	2227	500	4454	1000
34.5	400	Transformer	668	150	—	—
	1200	Transformer	668	150	1336	300
	1200	Interchangeable	1336	300	2672	600
	2000	Circuit breaker	1781	400	3563	800
	3000	Circuit breaker	2227	500	4454	1000
46	400	Transformer	668	150	—	—
	1200	Transformer	668	150	1336	300
	1200	Interchangeable	1336	300	2672	600
	2000	Circuit breaker	1781	400	3563	800
69	400	Transformer	668	150	—	—
	1200	Transformer	668	150	1336	300
	1200	Interchangeable	1336	300	3563	800
	2000	Circuit breaker	1781	400	5344	1200
115/138	1200/1600	Interchangeable	3118	700	6235	1400
	1600/2000	Interchangeable	3118	700	6235	1400
	2500/3000	Interchangeable	4008	900	8016	1800
161	1600/2000	Interchangeable	4008	900	8016	1800
	2500/3000	Interchangeable	4454	1000	8907	2000
	4000	Circuit breaker	5344	1200	10689	2400

Table continues

Table A.1—TBI bushing cantilever test requirements (continued)

Nominal system voltage	Rated continuous current		Design test [a]			
			Top transverse force static values		Bottom transverse force static values [b]	
(kV)	(A)		(N)	(lbf)	(N)	(lbf)
196	1600/2000	Interchangeable	4008	900	8016	1800
	2500/3000	Interchangeable	5344	1200	10689	2400
230	1600	Transformer	4008	900	8016	1800
345	1600	Transformer	4008	900	8016	1800

[a]These are design test requirements only and are not associated with permissible loads that can be applied to the top end terminal of bushings in service.

[b]Permanent deformation, measured at the bottom end 1 min after removal of the load, shall not exceed 0.76 mm (0.03 in).

Annex B

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] IEC 60137, Standard for Insulating Insulated Bushings forAlternating Voltages Above 1000 V.[5]

[B2] IEEE Std C57.12.90™, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.[6,7]

[5]At the time of publication of this standard, there were no equivalent dimensional standards in IEC 60137. IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).
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