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An American National Standard

IEEE Standard Electrical, Dimensional, and Related Requirements for Outdoor Apparatus Bushings

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Foreword

[This foreword is not part of IEEE Std 24-1977, IEEE Electrical, Dimensional, and Related Requirements for Outdoor Apparatus Bushings (ANSI C76.2-1977).]

This publication is based on the standard practices in the United States for outdoor apparatus bushings. It is the result of joint efforts of professional engineers, manufacturers, and users working together in American National Standards Committee C76 under the auspices of the American National Standards Institute (ANSI). The work was initially carried out under the auspices of the American Institute of Electrical Engineers (AIEE) [now the Institute of Electrical and Electronics Engineers (IEEE)] and the National Electrical Manufacturers Association (NEMA). The original standard, approved in 1942 as AIEE Std 21 (which became ASA C76.1-1943, American Standard for Apparatus Bushings) was prepared by the Joint Committee on Bushing Standardization of the Electric Machinery, Power Transmission and Distribution, and Protection Devices Committees of the AIEE.

A supplement and partial revision, ANSI C76.1-1958, American National Standard Electrical and Dimensional Characteristics of Outdoor Apparatus Bushings (used with Power Circuit Breakers and Outdoor Transformers), was prepared by the NEMA Joint Sections Committee on Outdoor Apparatus Bushings (composed of representatives of the High Voltage Insulator Section, Power Circuit Breakers Group, Switchgear Section, and the Transformer Section). It resulted from work by the regional associations of electrical utilities and filled the user's needs for dimensional interchangeability.

At the time of this supplement, ASA Sectional Committee C76 foresaw the need for a general revision and updating of the standard and asked AIEE and NEMA to submit recommendations. In NEMA, implementation of this request was undertaken by a Subcommittee of the Joint Sections Committee on Outdoor Apparatus Bushings and resulted in a proposal which was approved February 1960 by the Codes and Standards Committee for submission to C76 as the NEMA recommendation. In the AIEE a Joint Working Group consisting of members of the Transformer and Dielectric Test Committee of the Transformer Committee and of the Power Circuit Breaker Committee was established and developed a recommendation which was submitted to C76 in July 1960. The AIEE proposal was subsequently reviewed by the West Coast Subcommittee of the AIEE Transformers Committee which developed additional recommendations and submitted them to ASA Committee C76 in November 1960. Committee C76 appointed a special Working Group for Revision of C76.1 to consolidate the several proposals and recommendations. This became IEEE Std 21-1964 and was approved June 9, 1964, as ANSI C76.1-1964, American National Standard Requirements and Test Code for Outdoor Apparatus Bushings, ASA C76.1-1964; it was reaffirmed in 1970.

Work on a revision was initiated in Committee C76 in August 1968. A decision was made to separate the standard into three parts; the first (C76.1-1976) to cover the general requirements and test procedures, the second (C76.2-1976) to cover explicit ratings and dimensions, and the third to be an application guide. The latter is still under consideration. Other changes in this revision included: (1) test procedure updating, (2) adding 362 through 800 kV maximum system voltage bushing electrical ratings with wet switching impulse test values and coordination with switching surge sparkover values of arresters, and (3) establishing dual current ratings for 115 through 196 kV insulation class bushings, since circuit breakers have a lower temperature rise, permitting a larger current rating for a given maximum ambient temperature compared with transformers.

The American National Standards Committee on Apparatus Bushings Standardization, C76, had the following personnel at the time it approved this standard:

W. F. Giles, Jr, *Chairman* **C. R. Muller,** *Secretary*

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J. L. Koepfinger	W. S. Morgan	W. T. Wintringham†

†Deceased

Contents

An American National Standard

IEEE Standard Electrical, Dimensional, and Related Requirements for Outdoor Apparatus Bushings

1. Scope

This standard covers electrical, dimensional, and related requirements for outdoor power class apparatus bushings which have basic impulse insulation levels of 110 kV and higher. It provides specific values for dimensional and related requirements which are to be interpreted, measured, or tested in accordance with IEEE Std 21-1976, IEEE General Requirements and Test Procedure for Outdoor Apparatus Bushings (ANSI C76.1-1976).

Bushings covered by this standard are intended for use as components of oil-filled transformers, oil-filled reactors, and oil circuit breakers.

2. Referenced Documents

The following standard forms a part of this standard to the extent specified herein:

IEEE Std 21-1976, IEEE General Requirements and Test Procedure for Outdoor Apparatus Bushings (ANSI C76.1-1976).

3. General Requirements

See IEEE Std 21-1976 (ANSI C76.1-1976) for general requirements, definitions, and methods of measurement or test applying to the detail requirements given in Section 4 of this document.

4. Detail Requirements

Outdoor apparatus bushings conforming to this standard shall meet the requirements of the following as applicable:

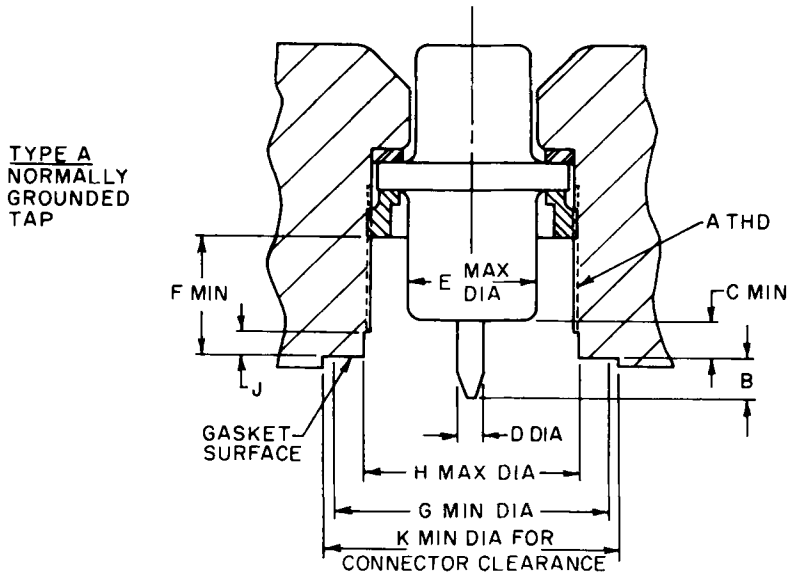
(1) Electrical insulation characteristics of Tables 1 or 2

(2) Dimensions of Tables 3 through 7, and Fig 1

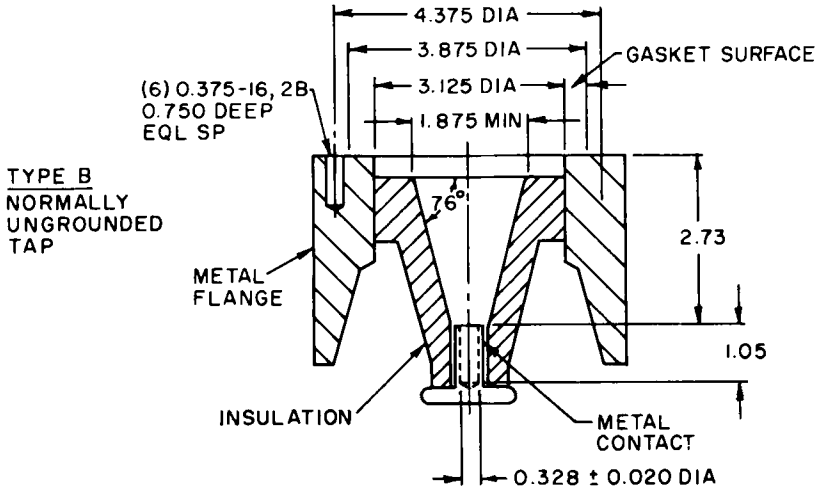
(3) Cantilever test of Table 8

(4) Radio influence voltage limits of Table 9

(5) Power factor limits of Table 10



A	2.250-12 UNF 2A	F	1 in
B	0.375 MIN-0.750 MAX	G	2.940
C	0.310	H	2.266 ± 0.003
D	0.313 ± 0.003	J	0.125 MIN-0.290 MAX
E	1.750	K	3.030



NOTE: Bushing potential device conversion kits are not covered by this standard. They may be used to connect the potential device to either Type A or Type B potential tap. The manufacturer of the potential device should be consulted for details.

Fig 1
Bushing Potential Tap Dimensions
(A) Type A: Normally Grounded Tap (B) Type B: Normally Ungrounded Tap

Table 1
Electrical Insulation Characteristics for Outdoor Power Apparatus Bushings (Insulation Class 15 kV through 196 kV)

Line No.	Insulation Class (kV)	BIL (kV)	Rated Maximum Line-to-Ground Voltage (kV)	Creep Distance Minimum (in)	Withstand Tests				
					60 Hz		Impulse		
					1 min Dry rms (kV)	10 s Wet rms (kV)	Full Wave (kV)	Chopped Wave — kV Crest Minimum Time to Sparkover	
								2 μs Withstand	3 μs Withstand
1	15	110	10	11	50	45	110	142	126
2	25	150	16	17	60	50	150	194	172
3	34.5	200	22	26	80	75	200	258	230
4	46	250	29	35	105	95	250	322	288
5	69	350	44	48	160	140	350	452	402
6	92 TR*	450	73	66	185	155	450	—	520
7	115	550	88	79	260	230	550	710	632
8	138	650	102	92	310	275	650	838	748
9	161	750	146	114	365	315	750	968	862
10	196	900	146	140	425	350	900	1160	1040

NOTES: (1) If flashover tests are required, a parallel test gap shall be used to limit the applied voltage to not more than 105 percent of the withstand voltage given in this table.

(2) The insulation class values given in this table are used merely as reference numbers and do not necessarily imply a relation to specific operating voltages.

*For transformers only.

Table 2
Electrical Insulation Characteristics for Outdoor Power Transformer Bushings (Maximum System Voltage: 362 kV and above)

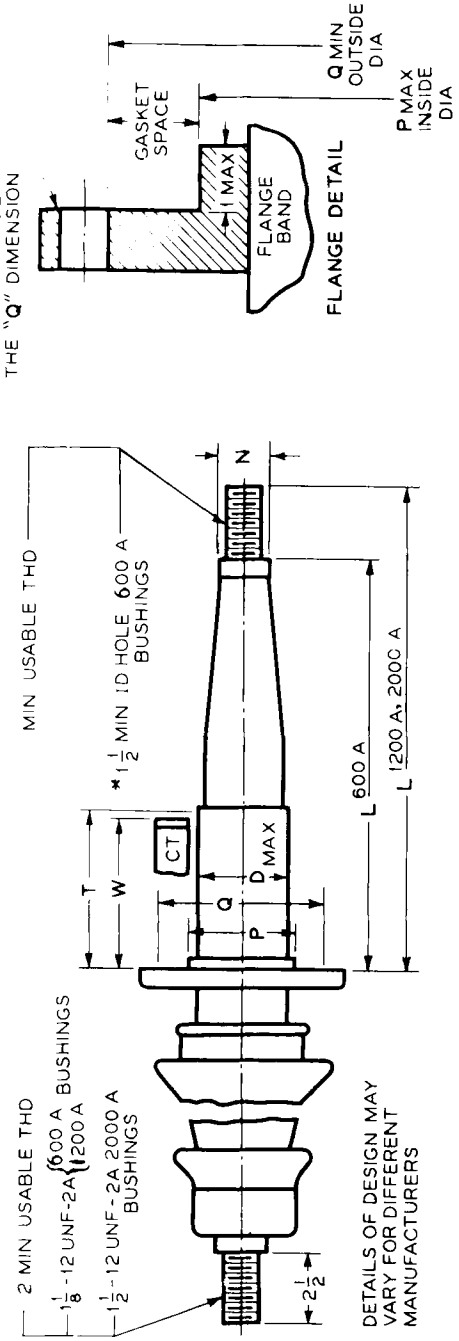
Line No.	BIL (kV)	Maximum System Voltage (kV)	Rated Maximum Line-to-Ground Voltage (kV)	Creep Distance Minimum (in)	Withstand Test				
					60 Hz 1 min Dry (kV)	Lightning Impulse			Switching Impulse Wet (kV)
						Full Wave (kV)	Chopped Wave		
							Crest (kV)	Minimum Time to Flashover (μs)	
1	900	362	220	220	395	900	1035	3	700
2	1050	362	220	220	460	1050	1210	3	825
3	1175	362	220	220	520	1175	1350	3	825
4	1300	550	318	318	575	1300	1500	3	1050
5	1425	550	318	318	630	1425	1640	3	1110
6	1550	550	318	318	690	1550	1780	3	1175
7	1675	550	318	318	750	1675	1925	3	1175
8	1800	800	485	485	800	1800	2070	3	1360

NOTES: (1) If flashover tests are requried, a parallel test gap shall be used to limit the applied voltage to not more than 105 percent of the withstand voltage given in this table.

(2) Dry negative switching impulse withstand voltage of the bushing must be at least equal to the dry switching surge withstand voltage specified in IEEE Std 262-1973, IEEE Test Code for Distribution, Power, and Regulating Transformers (ANSI C57.12.90-1973), and IEEE Std 462-1973, IEEE General Requirements for Distribution, Power, and Regulatory Transformers (ANSI C57.12.00-1973).

(3) In applying bushings, the margin over the voltages permitted by the surge arrester should be checked. If the withstand voltage value listed in the column labeled "Switching Impulse Wet" is less than 1.15 times the switching surge sparkover value of the arrester, a higher rated bushing should be used.

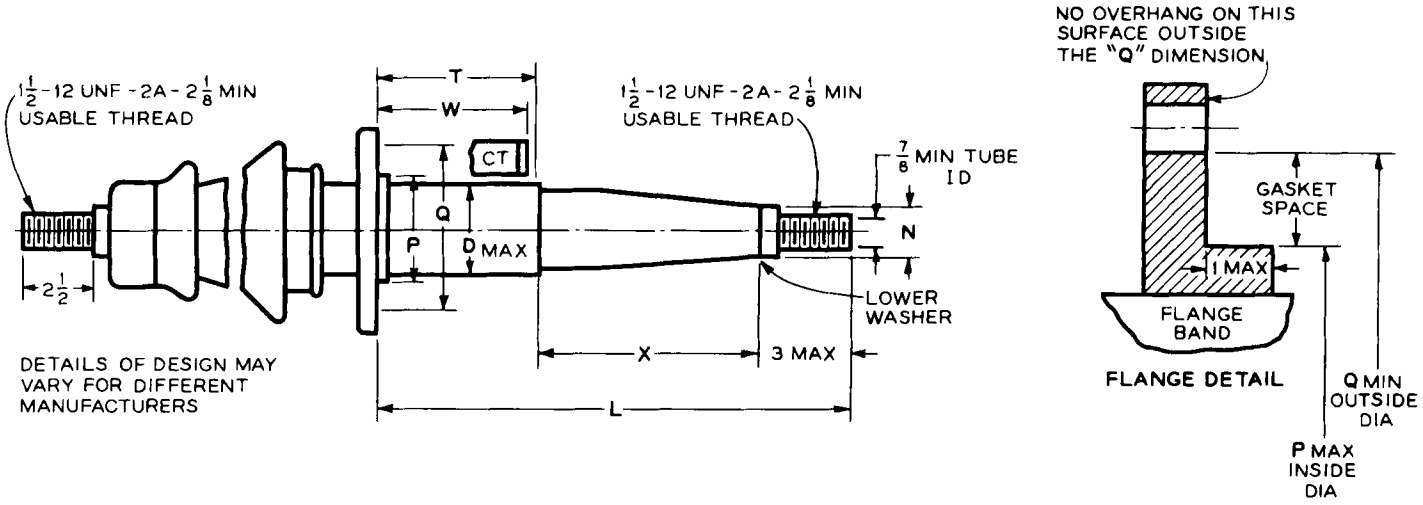
Table 3
Dimensions of 15 kV Transformer Cover-Mounted Bushings



Insulation Class (kV)	BIL (kV)	Rated Continuous Current (A)	L	T	W	D (max)	Bottom End Terminal		Flange					Top End Terminal	
							Thread	Usable Thread	P	Q	No. of Bolt Holes	Bolt Hole Size	Bolt Circle Diameter	Usable Thread	Thread
15	110	600	13½	10	10	3⅛	See Diagram		3⅜	5⅛	4	⅝	6	2	1⅛—12
			20	16½	16½										
			24½	21	21										
15	110	1200	16½	10	10	3⅛	1⅛—12	1½	3¾	5⅛	4	⅝	6	2	1⅛—12
			23	16½	16½										
			27½	21	21										
15	110	2000	17	10	10	4	1½—12	2	4¼	6¼	4	⅝	7¼	2	1½—12
			23½	16½	16½										
			28	21	21										

NOTE: All dimensions are given in inches.

Table 4
Dimensions of Outdoor Power Apparatus Bushings for Outdoor Oil-Type Transformers and Circuit Breakers
(Insulation Class: 23/25 through 69 kV)



Line No.	Rating: Insulation Class (kV)	Rating: Basic Impulse Level (kV)	Rating: Rated Continous Current (A)*	Lower End: Length of Bushing from Flange Seat to Lower End ± ⅛ L	Lower End: Minimum Insulation Length, For Use in Circuit Breakers X	Lower End: Depth (W) of Current Transformer Pocket and Distance (T) from Bushing Gasket Surface to Minimum Oil Level, For Use in Circuit Breakers W and T	Lower End: Depth (W) of Current Transformer Pocket and Distance (T) from Bushing Gasket Surface to Minimum Oil Level, For Use in Transformers W	Lower End: Depth (W) of Current Transformer Pocket and Distance (T) from Bushing Gasket Surface to Minimum Oil Level, For Use in Transformers T	Lower End: Diameter from 1 in below Flange to Lower End of Bushing Maximum D	Lower End: Diameter of Lower Washer Maximum N	Flange: Gasket Space, Maximum Inside Diameter P	Flange: Gasket Space, Minimum Outside Diameter Q	Flange: Provision for Bolts, No.	Flange: Provision for Bolts, Bolt Hole Size	Flange: Provision for Bolts, Bolt Circle Diameter
1	23/25	150	400/1200	29½	9½	16½	16½	21	3⅛	3⅛	4	6¼	4	⅞	7¼
2	34.5	200	400/1200	31½	11½	16½	16½	21	3½	3½	4	6¼	4	⅞	7¼
3	46	250	400/1200	33½	13½	16½	16½	21	4	4	5	7¼	4	⅞	8¼
4	69	350	400/1200	37½	17½	16½	16½	21	5¼	4	6	8¼	6	⅞	9¼

NOTES: (1) All dimensions are given in inches.
(2) The oil gage and test tap when supplied shall be in line and midway between two adjacent flange bolt holes.
*Bushing design provides for 400 A maximum in draw lead or 1200 A bottom connected.

Table 5
Dimensions of Outdoor Power Apparatus Bushings for Outdoor Oil-Type Transformers
(Insulation Class: 23/25 through 69 kV)
(Not Applicable to Circuit Breakers)

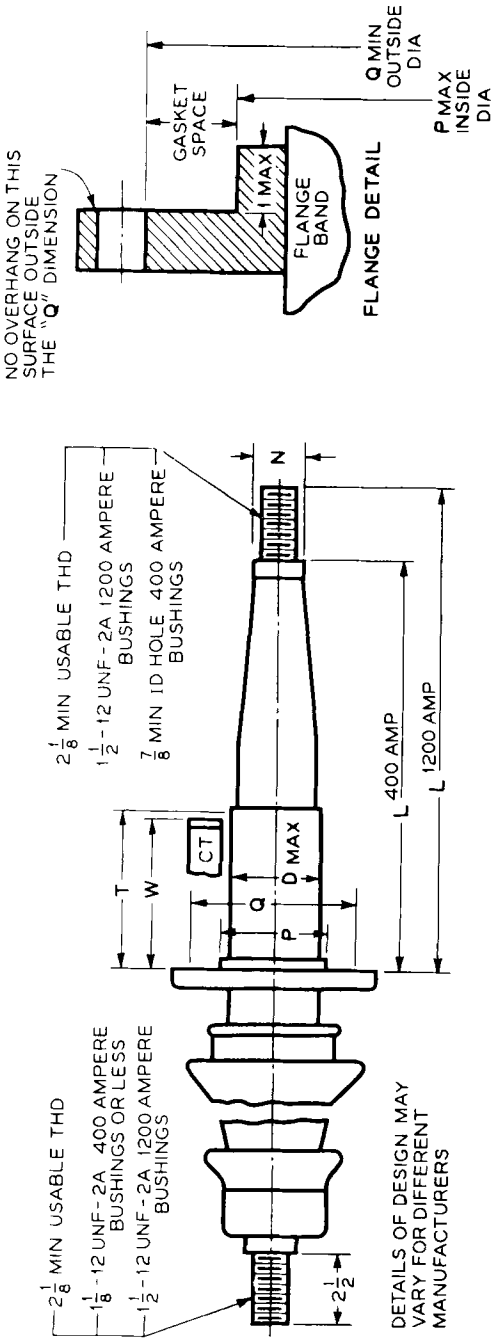


Table 5 (continued)

Line No.	Rating: Insulation Class (kV)	Rating: Basic Insulation Level (kV)	Rating: Rated Continuous Current (A)	Lower End: Length of Bushing from Flange Seat to Lower End ± ⅛ L	Lower End: Depth of Current Transformer Pocket and Distance from Bushing Gasket Surface to Minimum Oil Level W and T	Lower End: Maximum Diameter from 1 in below Flange to Lower End of Bushing D	Lower End: Diameter of Lower Washer Maximum N	Lower End: Inside Diameter Tube Minimum	Lower End: Usable Thread	Lower End: Thread Class UNF—2A	Flange: Gasket Space: Inside Diameter Maximum P	Flange: Gasket Space: Outside Diameter Minimum Q	Flange: Provision for Bolts: No.	Flange: Provision for Bolts: Bolt Hole Size	Flange: Provision for Bolts: Bolt Circle Diameter
1	23/25	150	400	16½	10	3⅛	3⅛	⅞	2⅛	1½—12	4	6¼	4	⅞	7¼
2			400	23	16½										
3			400	27½	21										
4			1200	30½	21										
5			1200	36½	27										
6	34.5	200	400	18½	10	3½	3½	⅞	2⅛	1½—12	4	6¼	4	⅞	7¼
7			400	25	16½										
8			400	29½	21										
9			1200	32½	21										
10			1200	38½	27										
11	46	250	400	20½	10	4	4	⅞	2⅛	1½—12	5	7¼	4	⅞	8¼
12			400	27	16½										
13			400	31½	21										
14			1200	34½	21										
15			1200	40½	27										
16	69	350	400	30½	16½	5¼	4	⅞	2⅛	1½—12	6	8¼	6	⅞	9¼
17			400	35	21										
18			400	41	27										
19			1200	38	21										
20			1200	44	27										

NOTES: (1) All dimensions given in inches.
(2) See Table 4 for bushings interchangeable with circuit breakers.
(3) The oil gage and test tap when supplied shall be in line midway between two adjacent flange bolt holes.
*Draw lead bushings.

Table 6
Dimensions of Outdoor Power Apparatus Bushings for Outdoor Oil Transformers and Circuit Breakers
(Insulation Class: 115 kV through 196 kV)

Line No.	Rating				Lower End					Flange					Top End Terminal	
	Insulation Class (kV)	BIL (kV)	Rated Continuous Current§ (A)		Length of Bushing from Flange Seat to Lower End ± 1/8 L	Depth of Current Transformer Pocket and Distance from Bushing Gasket Surface to Minimum Oil Level W	Maximum Diameter from 1 in below Flange to Lower End of Bushing D	Bottom End Terminal‡		Gasket Space		Provision for Bolts‡			Usable Engagement Length Minimum A	Thread Class UNF-2A R
			Transformer	Breaker				Inside Diameter Tube Minimum	Detail D Fig No▲	Inside Diameter Maximum P	Outside Diameter Minimum Q	No	Bolt Hole Size	Bolt Circle Diameter		
1	115*	550	1200	1600	43	23	8¾	1½	(2)	9⅞	11⅞	6	1¼	13¼	2	1½—12
2	115*	550	1600	2000	43	23	9¾	†	(3)	9⅞	11⅞	6	1¼	13¼	2½	2—12
3	115	550	2500	—	43	23	9¾	†	(3)	9⅞	11⅞	6	1¼	13¼	3	3—12
4	138*	650	1200	1600	46¾	23	9¾	1⅝	(2)	10⅞	12⅞	6	1¼	14¼	2	1½—12
5	138*	650	1600	2000	46¾	23	9¾	†	(3)	10⅞	12⅞	6	1¼	14¼	2½	2—12
6	138	650	2500	—	46¾	23	10¾	†	(3)	10⅞	12⅞	6	1¼	14¼	3	3—12
7	161*	750	1200	1600	50¼	23	12	1⅝	(2)	12⅜	14⅜	8	1¼	15¾	2	1½—12
8	161*	750	1600	2000	50¼	23	12	†	(3)	12⅜	14⅜	8	1¼	15¾	2½	2—12
9	161	750	2500	—	50¼	23	12	†	(3)	12⅜	14⅜	8	1¼	15¾	3	3—12
10	196*	900	1200	1600	59½	26¾	14⅝	2	(3)	17⅛	19½	12	1¼	21	2	1½—12
11	196*	900	1600	2000	59½	26¾	14⅝	†	(3)	17⅛	19½	12	1¼	21	2⅓	2—12
12	196	900	2500	—	59½	26¾	14⅝	†	(3)	17⅛	19½	12	1¼	21	3	3—12

NOTE: All dimensions are given in inches.

*These bushings are dimensionally interchangeable between circuit breakers and transformers. Dimensional interchangeability does not necessarily imply mechanical or electrical interchangeability on apparatus of different manufacturers.

†Not designed for use with draw lead.

§ For draw lead application, the continuous current rating is limited to the current rating of the draw lead applied by the equipment manufacturer.

‡ When furnished, oil gage and potential tap are in line midway between two adjacent flange bolt holes and between two adjacent bottom end tapped holes.

▲Table 6 Detail D Fig 2 bottom terminal may be converted to Table 6 Detail D Fig 3 bottom terminal by threading on a proper adapter.

Table 6 (continued)

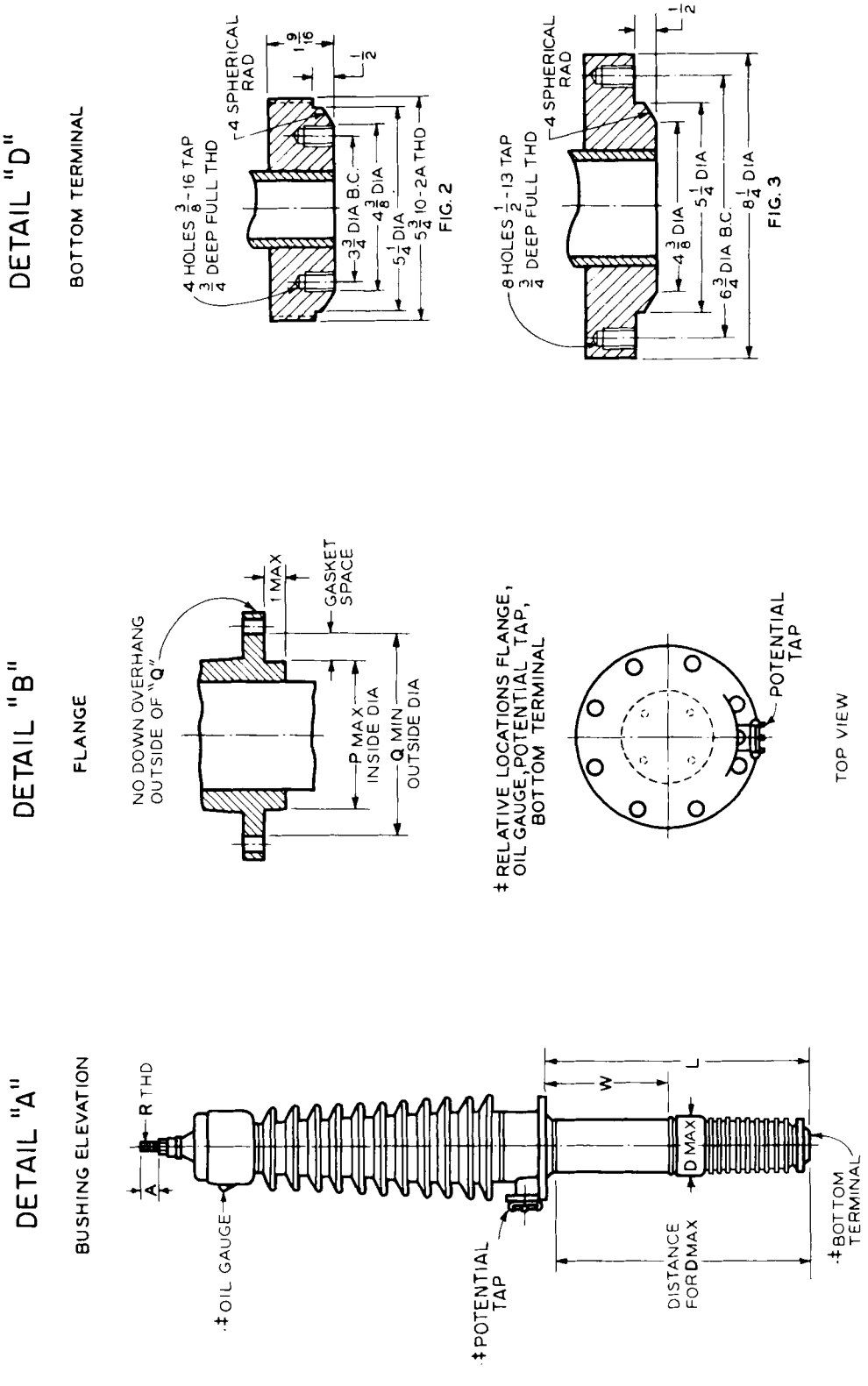


Table 7
Dimensions of Outdoor Power Transformer Bushings
(Maximum System Voltage: 362 kV and above)

	Rating		Lower End					Flange					Top End Terminal	
						Bottom End Terminal Fig 4		Gasket Space		Provision for Bolts				
Line No.	BIL (kV)	Rated Continuous Current (A)	Length of Bushing from Flange Seat to Lower End ± ⅜ in L	Depth of Current Transformer Pocket and Distance from Bushing Gasket Surface to Minimum Oil Level W	Diameter from 1 in below Flange to Lower End of Bushing Maximum D	Inside Tube Diameter Minimum	Washer Diameter Maximum N	Inside Diameter Maximum P	Outside Diameter Minimum Q	No.	Bolt Hole Size	Bolt Circle Diameter	Usable Thread Length Minimum A	Thread Class UNF-2A B
1	900	*	—	—	—	—	—	—	—	—	—	—	—	—
2	900	1600	—	—	—	—	—	—	—	—	—	—	—	—
3	1050	*	51	23	15¾	2	8¼	17⅛	19½	12	1¼	21	2½	2—12
4	1050	1600	51	23	15¾	†	8¼	17⅛	19½	12	1¼	21	2½	2—12
5	1175	*	—	—	—	—	—	—	—	—	—	—	—	—
6	1175	1600	—	—	—	—	—	—	—	—	—	—	—	—
7	1300	1600	—	—	—	—	—	—	—	—	—	—	—	—
8	1425	1600	65	27	20	†	12	21	23	12	1¼	25	2½	2—12
9	1550	1600	—	—	—	—	—	—	—	—	—	—	—	—
10	1675	1600	—	—	—	—	—	—	—	—	—	—	—	—
11	1800	1600	—	—	—	—	—	—	—	—	—	—	—	—

NOTE: Dashes indicated data under consideration.
Letters in dimension column headings refer to diagram Table 6.
*Continuous current rating limited by size of transformer draw lead.
†Not designed for use with draw lead.

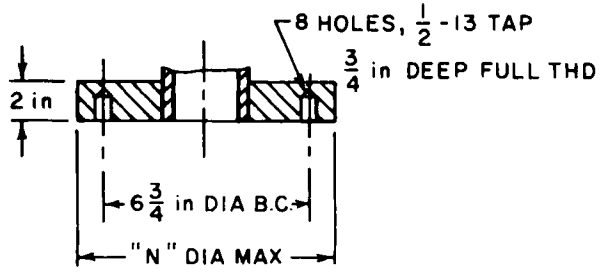


Table 8
Cantilever Test Requirements for Outdoor Power Apparatus Bushings

Insulation Class (kV)	Rated Continuous Current Application (A)	Design Test*	
		Top Transverse Force Static Values (lb)	Bottom Transverse Force Static Values (lb)
23/25	400 Transformer	150	—
	1200 Transformer	150	300
	1200 Interchangeable	300	600
	2000 Circuit breaker	400	800
	3000 Circuit breaker	500	1000
	4000 Circuit breaker	500	1000
34.5	400 Transformer	150	—
	1200 Transformer	150	300
	1200 Interchangeable	300	600
	2000 Circuit breaker	400	800
	3000 Circuit breaker	500	1000
46	400 Transformer	150	—
	1200 Transformer	150	300
	1200 Interchangeable	300	600
	2000 Circuit breaker	400	800
69	400 Transformer	150	—
	1200 Transformer	150	300
	1200 Interchangeable	300	800
	2000 Circuit breaker	400	1200
115	1200/1600 Interchangeable	700	1400
	1600/2000 Interchangeable	700	1400
	2500/3000 Interchangeable	900	1800
138	1200/1600 Interchangeable	700	1400
	1600/2000 Interchangeable	700	1400
	2500/3000 Interchangeable	900	1800
161	1600/2000 Interchangeable	900	1800
	2500/3000 Interchangeable	1000	2000
	4000 Circuit breaker	1200	2400
196	1600/2000 Interchangeable	900	1800
	2500/3000 Interchangeable	1200	2400
230	1600 Transformer	900	1800
345	1600 Transformer	900	1800

*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.

Table 9
Radio Influence Voltage Limits

Insulation Class (kV)	Radio Influence Voltage (μV)
15	50
23/25	100
34.5	150
46	200
69	300
92	400
115	450
138 and above	500

NOTES: (1) These allowable radio influence voltage values include background level.

(2) A resin-bonded paper-insulated bushing, when tested at rated line-ground voltage, shall not create radio influence voltage in excess of values given in this table.

(3) Oil-impregnated paper-insulated bushings, when tested at rated line-ground voltage, shall not create radio influence voltage in excess of background level which shall not exceed 50 μV.

Table 10
Power Factor Limits

Bushing Type	Power Factor Limit (percent)
Resin-bonded paper-insulated	2
Oil-impregnated paper-insulated	1*

NOTES: (1) Power factor limits shall be referred to 25° C.

(2) Power factor measurements shall be made at 10 kV and the measured values shall not exceed the values listed.

*For oil-impregnated, paper-insulated bushings, the percent power factor after the 1 min dry withstand test shall not increase more than 0.02 over the initial value when measured at 10 kV and corrected to 25°C; for example, 0.50 percent power factor before, 0.52 percent power factor after.