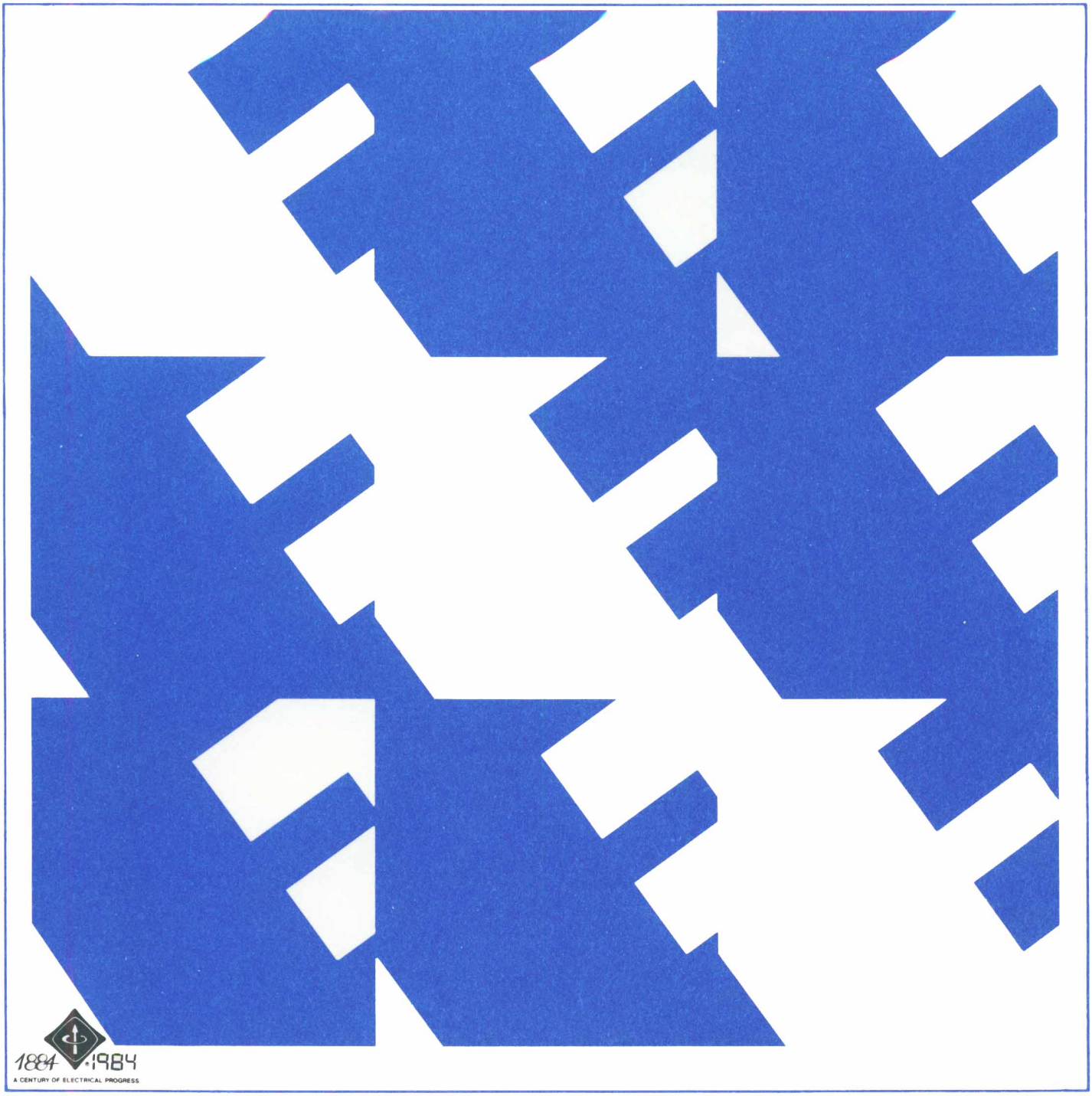
AMERICAN NATIONAL STANDARD

ANSI/IEEE Std 24-1984
(Revision of ANSI/IEEE
Std 24-1977)

IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings



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An American National Standard

IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings

Secretariat

Institute of Electrical and Electronics Engineers, Inc

Approved December 17, 1981

IEEE Standards Board

Approved August 5, 1983

American National Standards Institute

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 24-1984, IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings.)

In keeping with progress in the state of the art, The Bushing Subcommittee of the Transformers Committee revised Table 1, *Electrical Insulation Characteristics for Outdoor Power Apparatus Bushings,* and Table 9, *Partial Discharge* to make them compatible with the concepts of IEEE Std 262B-1977, IEEE Trial-Use Standard Dielectric Test Requirements for Power Transformers for Operation on Effectively Grounded Systems 345 kV and above.

The Bushing Subcommittee, of the Transformers Committee, had the following membership at the time this revision was developed and approved.

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An American National Standard

IEEE Standard Performance Characteristics and Dimensions 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 ANSI/IEEE Std 21-1976.

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

2. References

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

ANSI/IEEE Std 21-1976, IEEE General Requirements and Test Procedure for Outdoor Apparatus Bushings.

3. General Requirements

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

4. Detail Requirements

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

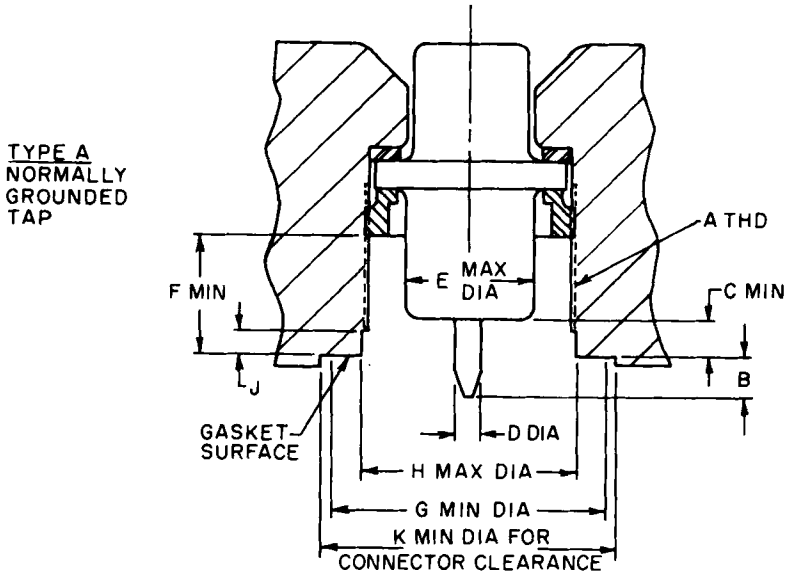
(1) Electrical insulation characteristics of Tables 1 or 2

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

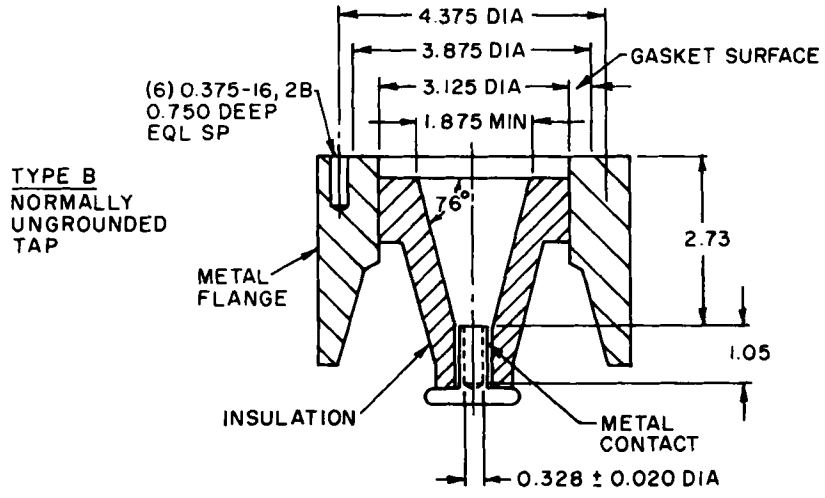
(3) Cantilever test of Table 8

(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)

BIL (kV)	Insulation Class (kV)	Rated Maximum Line-to-Ground Voltage (kV)	Creep Distance Minimum (in)	Creep Distance Minimum (cm)	Withstand Tests: 60 Hz: 1 Min Dry rms (kV)	Withstand Tests: 60 Hz: 10 s Wet rms (kV)	Withstand Tests: Impulse: Full Wave (kV)	Withstand Tests: Impulse: Chopped Wave — kV Crest Minimum Time to Sparkover: 2 μs Withstand	Withstand Tests: Impulse: Chopped Wave — kV Crest Minimum Time to Sparkover: 3 μs Withstand
110	15	10	11	28	50	45	110	142	126
150	25	16	17	43	60	50	150	194	175
200	34.5	22	26	66	80	75	200	258	230
250	46	29	35	89	105	95	250	322	290
350	69	44	48	122	160	140	350	452	402
450	92 TR*	73	66	166	185	155	450	—	520
550	115	88	79	201	260	230	550	710	632
650	138	102	92	234	310	275	650	838	750
750	161	102	114	290	365	315	750	968	865
750	161TR*	146	140	356	365	315	750	—	865
900	196	146	140	356	425	350	900	1160	1040

*For reduced BIL transformers only.

NOTES: (1) If flashover tests are required, a parallel test gap shall be used to limit the applied voltage to not more than 105% 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 operation voltages.

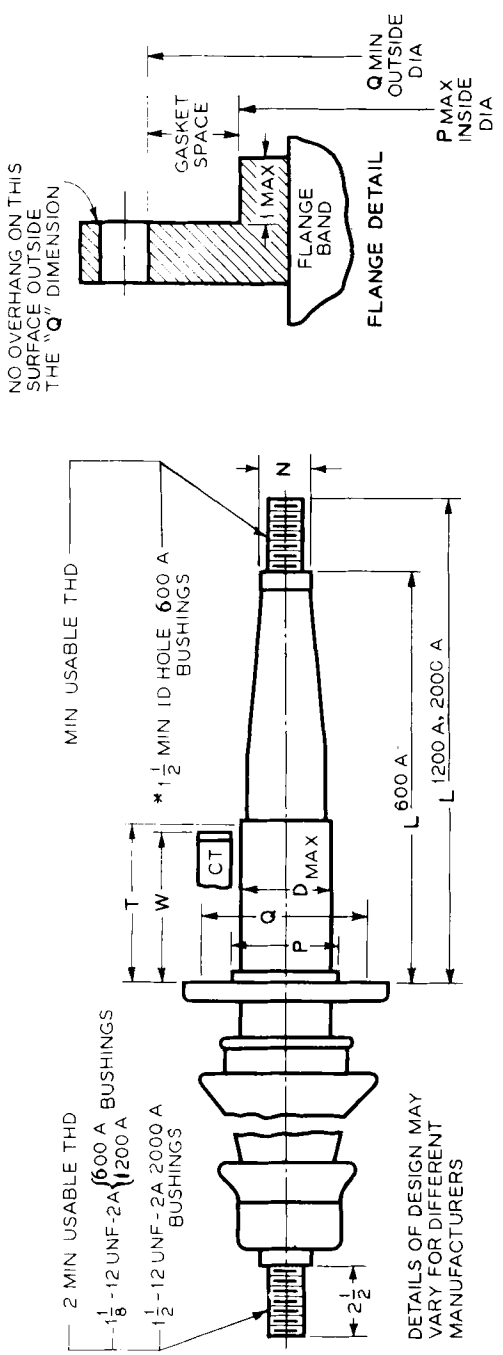
Table 2
Electrical Insulation Characteristics for Outdoor Power Transformer Bushings (Maximum System Voltage: 362 kV and Above)

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)	Withstand Test: Lightning Impulse: Full Wave (kV)	Withstand Test: Lightning Impulse: Chopped Wave: Crest (kV)	Withstand Test: Lightning Impulse: Chopped Wave: Minimum Time to Flashover (μs)	Withstand Test: Switching Impulse Wet (kV)
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 required, a parallel test gap shall be used to limit the applied voltage to not more than 105% 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 262B-1977, IEEE Trial-Use Standard Dielectric Test Requirements for Power Transformers for Operation on Effectively Grounded Systems 345 kV and Above, ANSI/IEEE C57.12.90-1980, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulation Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers, and ANSI/IEEE C57.12.00-1980, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

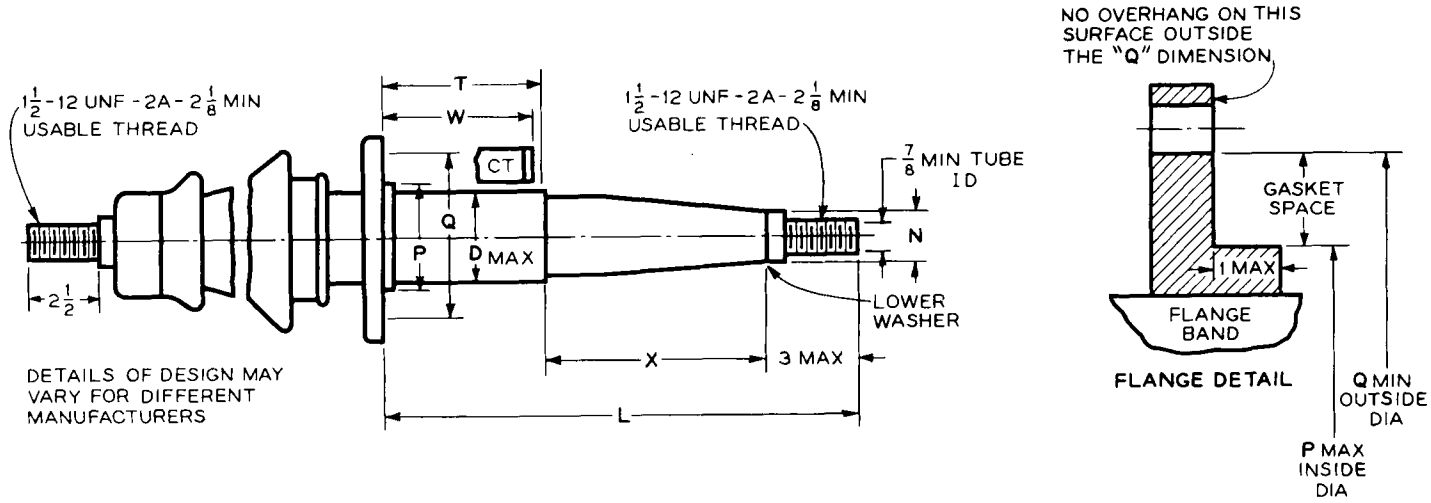
Table 3
Dimensions of 15 kV Transformer Cover-Mounted Bushings



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	Usable Thread	Thread
15	110	600	13½	10	10	3⅛	See Diagram		3⅜	5⅛	4	⅝	2	1⅛—12
			20	16½	16½									
			24½	21	21									
15	110	1200	16½	10	10	3⅛	1⅛—12	1½	3⅜	5⅛	4	⅝	2	1⅛—12
			23	16½	16½									
			27½	21	21									
15	110	2000	17	10	10	4	1½—12	2	4¼	6¼	4	⅝	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)

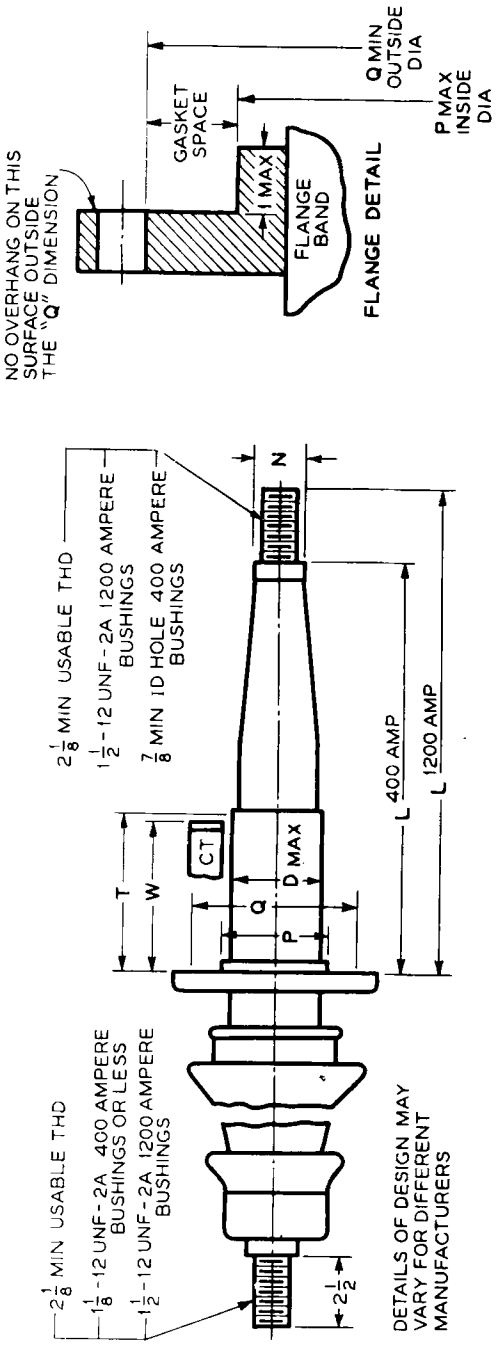


Table 5 (*continued*)
Dimensions of Outdoor Power Apparatus Bushings for Outdoor Oil-Type Transformers
(Insulation Class: 23/25 through 69 kV)
(Not Applicable to Circuit Breakers)

	Rating			Lower End							Flange				
											Gasket Space		Provision for Bolts		
Line No.	Insulation Class (kV)	Basic Insulation Level (kV)	Rated Continuous Current (A)	Length of Bushing from Flange Seat to Lower End ± ⅛ L	Depth of Current Transformer Pocket and Distance from Bushing Gasket Surface to Minimum Oil Level W and T	Maximum Diameter from 1 in below Flange to Lower End of Bushing D	Diameter of Lower Washer Maximum N	Inside Diameter Tube Minimum	Usable Thread	Thread Class UNF—2A	Inside Diameter Maximum P	Outside Diameter Minimum Q	No.	Bolt Hole Size	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)

					Lower End												
	Rating									Flange					Top End Terminal	
			Rated Continuous Current§ (A)		Length of Bushing from Flange Seat to Lower End ± 1/8	Depth of Current Transformer Pocket and Distance from Bushing Gasket Surface to Minimum Oil Level	Maximum Diameter from 1 in below Flange to Lower End of Bushing	Bottom End Terminal‡		Gasket Space		Provision for Bolts‡			Usable Engagement Length	
Line No.	Insulation Class (kV)	BIL (kV)	Transformer	Breaker	L	W	D	Inside Diameter Tube Minimum	Detail D Fig No▲	Inside Diameter Maximum P	Outside Diameter Minimum Q	No	Bolt Hole Size	Bolt Circle Diameter	Minimum A	Thread Class UNF-2A R
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*)

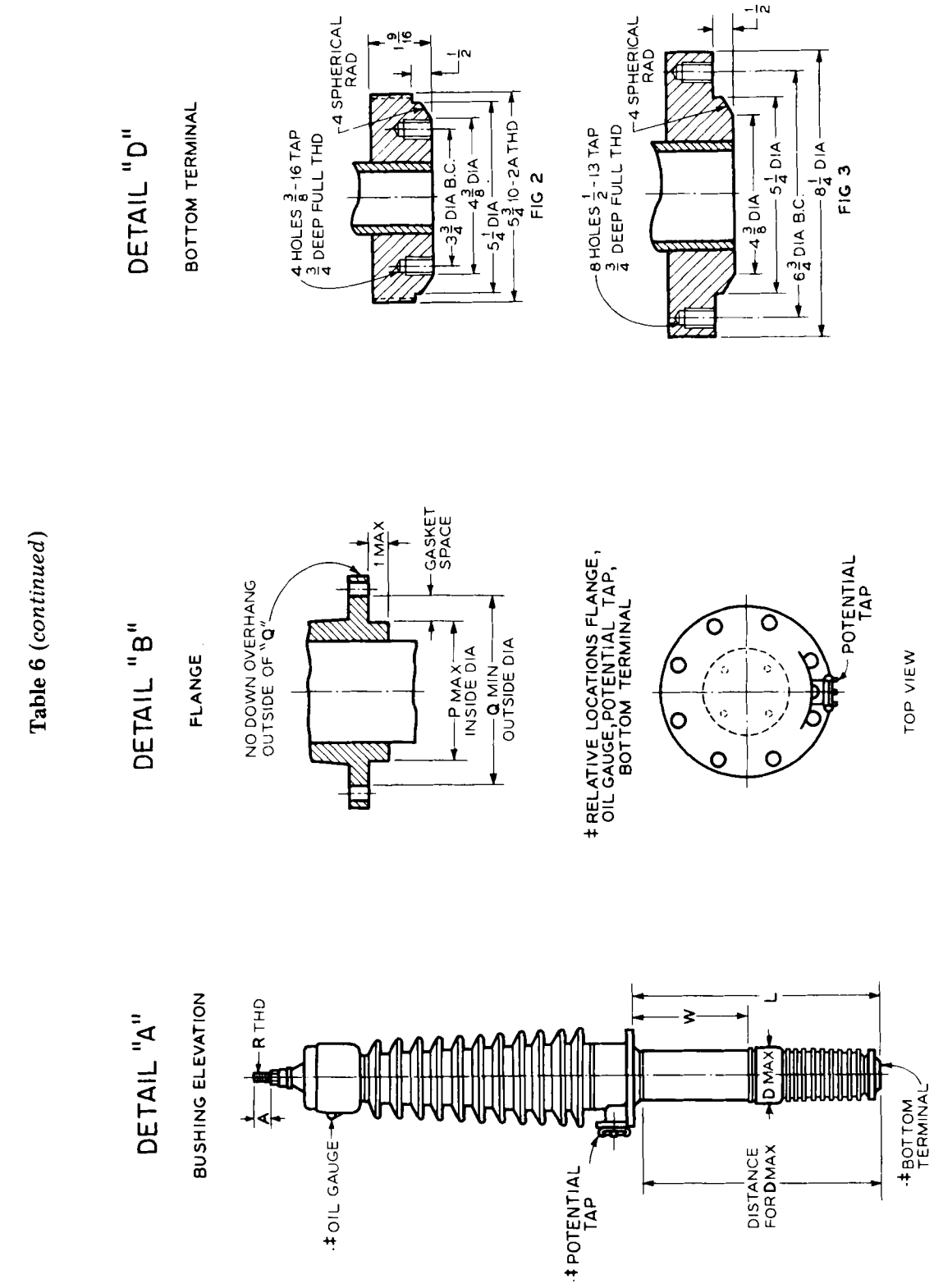


Table 7
Dimensions of Outdoor Power Transformer Bushings
(Maximum System Voltage: 362 kV and above)

	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 ± 3/8 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.

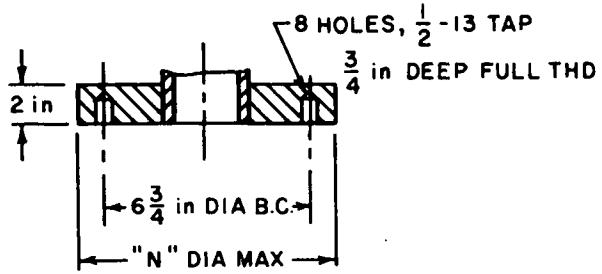


Table 8
Cantilever Test Requirements for Outdoor Power Apparatus Bushings

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
Partial Discharge
(Radio Influence Voltage) Limits*

Type of Construction**	Application	
	General Purpose	Power Transformers†
	At Maximum Line to Ground Voltage	At 1.5 · Maximum Line to Ground Voltage (1 h max)
Solid bushings		
General purpose	No limit established	Not applicable
Special partial discharge limits	Not applicable	50 μV
Resin bonded paper	50 μV	100 μV
Oil impregnated paper		
550 kV system and below	25 μV	25 μV
Above 550 kV system	50 μV	50 μV
Resin impregnated paper	25 μV	25 μV
Cast insulation	25 μV	25 μV

*These allowable radio influence voltage limits include background level. Since these measurements are related to partial discharges within the major insulation, external shielding may be used to reduce air corona which may occur at the bushing terminals or grounded projections.

**See ANSI/IEEE Std 21-1976, IEEE General Requirements and Test Procedure for Outdoor Apparatus Bushings, for definitions of types of construction.

†For application to power transformers which require partial discharge acceptance tests at 1.5 per unit of maximum line to ground voltage, bushings may be selected from appropriate types of construction and voltage ratings.

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.