
	<h2 style="margin: 0;">CAPACITORS FOR DISTRIBUTION LINES</h2>	<h2 style="margin: 0;">028425</h2>
Asset Type: Electric Distribution Issued by: (Eduardo C. Sanchez) 	Function: Construction and Design Date: 08-15-17	
Rev. #18: This document replaces PG&E Document 028425, Rev. #17. For a description of the changes, see Page 17.		

Purpose and Scope

This document provides information for:

- Ordering factory-assembled switched capacitor banks.
- Identifying components and ordering replacement parts for switched capacitor assemblies.

Application Information

1. The cost of switching equipment (switches, control device, control transformer, etc.) for automatically switched capacitors is independent of bank size. Therefore, in order to minimize the cost per kvar of switching equipment, the size of switched capacitor banks should be as large as practical.
2. Rack configuration is shown for new units purchased beginning in 1997.
3. Beginning in late 2004, all new switched capacitors now come with vacuum switches instead of oil switches.
4. Beginning in 2011, all switches purchased are no longer of porcelain material.

Supplier Notes

5. All new capacitor banks shall have capacitor units, potential transformers, and non-porcelain vacuum switches with stainless steel tanks and noncorrosive hardware. The frame and all hardware shall be T-6061 aluminum or other suitably noncorrosive material.
6. The minimum bushing creepage is 17 inches for the 12, 17, and 21 kV units.
7. Racks shall be self-supporting when placed on a level surface for transporting.
8. On all switched banks and fixed banks with more than three capacitor units, two adjustable sway brackets (see Figure 1 on Page 4) shall be provided that will accommodate pole diameters of 8" through 15".
Note: Sway brackets must attach to the capacitor side of the supporting pole.
9. Capacitors shall be shipped from the factory in a full crate so that they may be stacked for storage.
10. Potential transformers and switches must be adequately supported to prevent damage during shipping.
11. All wye-connected banks shall be configured as floating-wye. They shall have provisions for attaching a ground by the installing PG&E crew.
12. The equipment weight shall be shown on the rack.

References	Location	Document
Application and Control of Capacitors on Distribution Lines	OH: Capacitors/EPM	039586
Revenue-Class Instrument Transformers 0-500 kV ..	Electric Metering	054340
Pad-Mount Capacitor	UG-1: General	066197
Overhead Capacitor Bank Installations	OH: Capacitors	066200
Engineering Material Specification #4, "Primary Shunt Capacitors and Assemblies for Overhead Distribution Lines"	EMS-FRO	EMS4
Distribution Voltage Regulators and Boosters	OH:Transformers/EPM	015239

Switch Replacements

- Upon failure of an oil switch, replace all three with vacuum switches.
- Upon failure of a vacuum switch, replace just the one with a vacuum switch of the same type.
- Some switches may not meet height clearance requirements in existing installations. Verify the cutout in the open position clears the vacuum switch below (See [Document 066200](#)).

Table 1 Capacitor Bank Assembly Codes

Volts	Number of Units	Unit kvar	Bank kvar	Code	Approximate Weight (lbs.)
4,160 Y	3	100	300	266321	500
12,000 D	3	100	300	266348	500
	3	200	600	266298	550
	3	300	900	266299	600
	6	200	1,200	266300	750
	6	300	1,800	266309	900
17,200 Y	3	200	600	266339	500
	3	300	900	266340	550
	6	200	1,200	266341	700
20,780 Y (3- or 4-Wire)	3	100	300	261965	500
	3	200	600	266342	550
	3	300	900	266307	600
	6	200	1,200	266308	750
	6	300	1,800	266309	900

Table 2 Required Insulation of Capacitor Units, Switches, and Buses

Three-Phase Bank Voltage	Min BIL kV	Minimum Creepage Distance for Insulators (inches)	Minimum Air Clearance (inches)	
			Phase-to-Phase	Phase-to-Ground (frames and cases)
4,160	75	5-1/2	6-1/2	4
12,000	125	17	6-1/2	6
17,200	125	17	10 ¹	6
20,780	125	17	12 ¹	- ²

¹ Capacitor unit terminal-to-terminal clearance between metal parts will be 6-1/2 inches minimum.

² Clearance from terminal to capacitor case will be strike distance of 17-inch creepage bushing.

Table 3 Required Connections for Switched Capacitor Assemblies

Three-Phase Bank Voltage	Capacitor Rating		Connection
	Voltage	kvar	
4,160	2,400	100	Ungrounded Wye
12,000	12,000	100, 200, or 300	Delta
17,200	9,960		Ungrounded Wye
20,780-4W	12,000		Grounded Wye
20,780-3W	12,000		Ungrounded Wye

Table 4 Acceptable Ampere Readings for Capacitor Banks

Bank kvar	Circuit Voltage			
	4 kV	12 kV	17 kV	21 kV
300	39-52	13-18	9-13	7-11
600	79-103	27-36	19-25	15-21
900	-	41-54	28-37	23-31
1,200	-	54-71	38-50	31-41
1,800	-	82-107	-	47-62

Capacitor Bank Parts

Notes

1. The cable from each switch shall have a 4-inch bare section for grounding.
2. A #6 bare copper ground wire shall connect each switch tank and the PT tank to the rack ground.

Table 5 Switched Capacitor Bank Components

Item	Description	Code
1	Capacitor Unit (see Table 11 on Page 15)	-
2	Rack With Pole Mounting Frame	-
3	Capacitor Switch (See Figures 10, 11 or 12)	-
4	Junction Box	-
5	Potential Transformer With Animal Guard (see Table 7 on Page 10)	-
6	Mounting Bracket	-
7	Rack Ground Terminal	-
8	Sway Bracket (see Figure 1 below)	-
9	Capacitor Protective Cap	262643
10	Switch Protective Cap	-
11	Transformer Protective Cap	-
12 ¹	Protective Tubing	-
13 ¹	#4 Solid Copper Wire (medium hard)	-
14	#4 Solid Raptor Lead Wire (290288)	290288
15	Connector and Cable for Capacitor Switch (261976) (not shown)	261976
16 ¹	#4 Solid Copper Wire	-

¹ #4 solid raptor lead wire may be substituted for the bare conductor with tubing or ground wire.

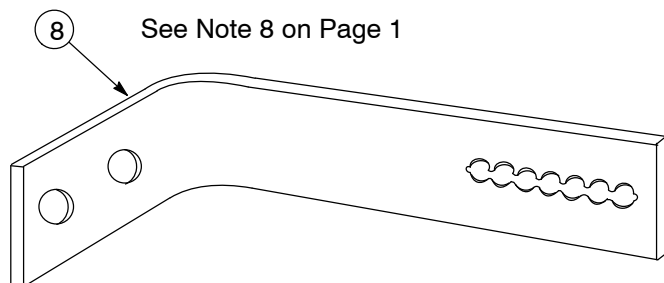
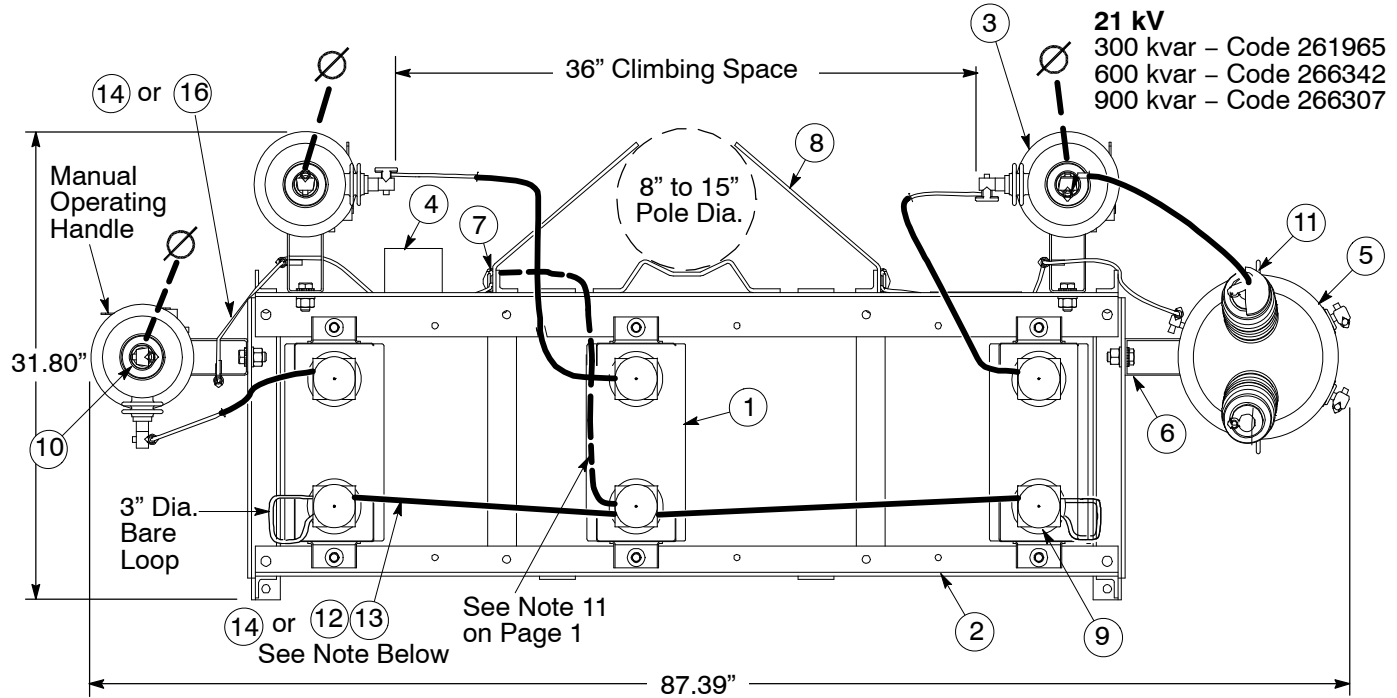


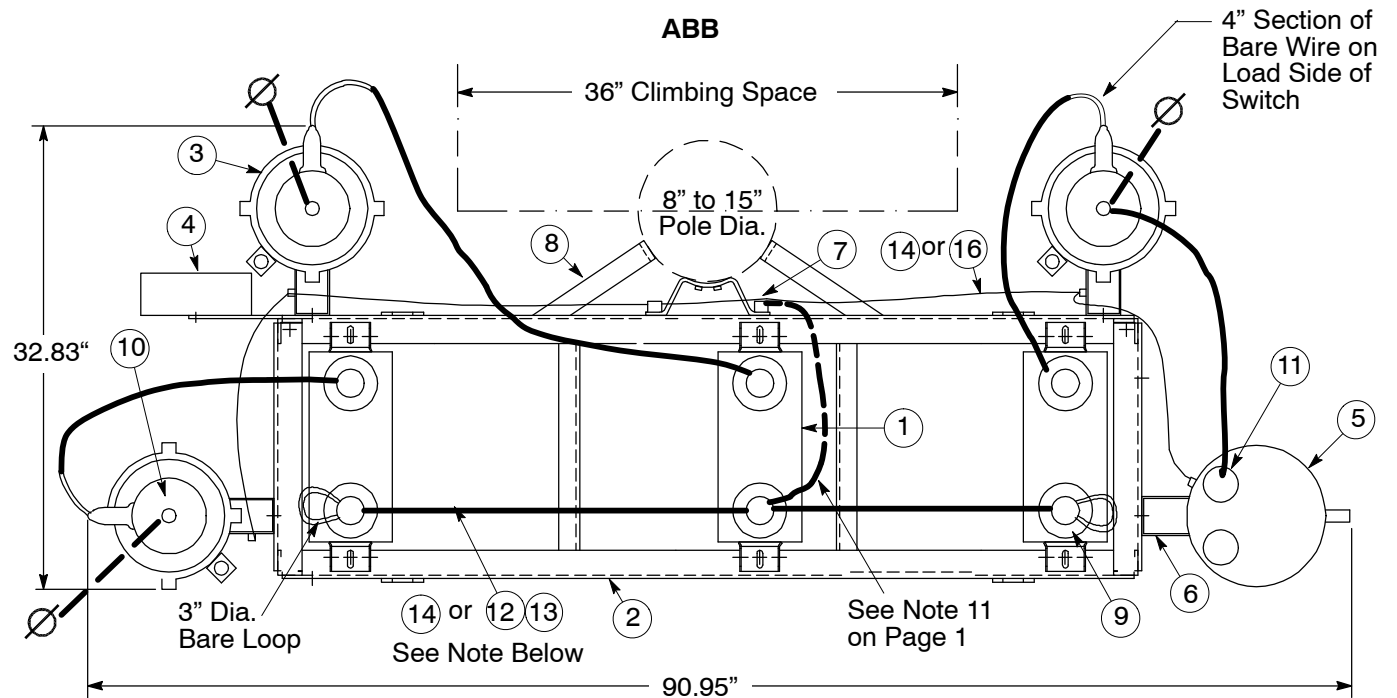
Figure 1
Capacitor Sway Bracket

Switched, Wye Connected, 3-Capacitor Unit Banks

- 4 kV**
300 kvar – Code 266321
- 17 kV**
600 kvar – Code 266339
900 kvar – Code 266340
- 21 kV**
300 kvar – Code 261965
600 kvar – Code 266342
900 kvar – Code 266307



ABB



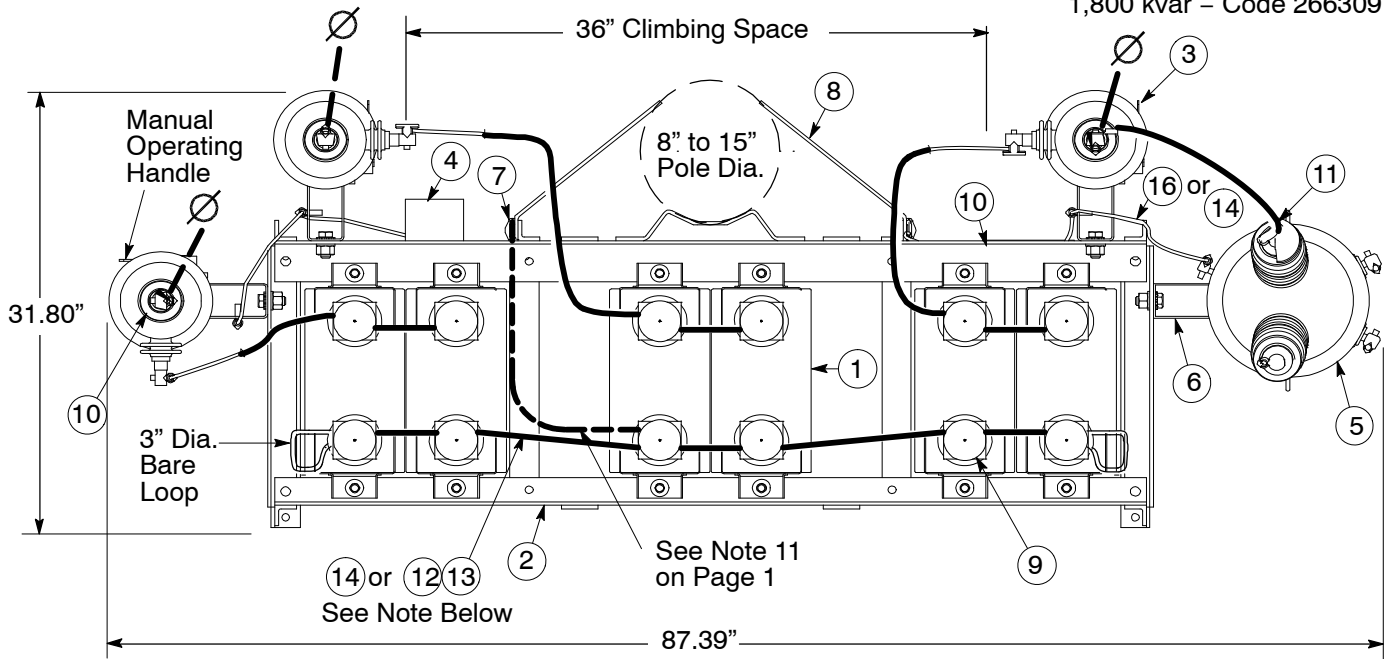
Cooper/Agile

**Figure 2
Switched 3-Unit Wye**

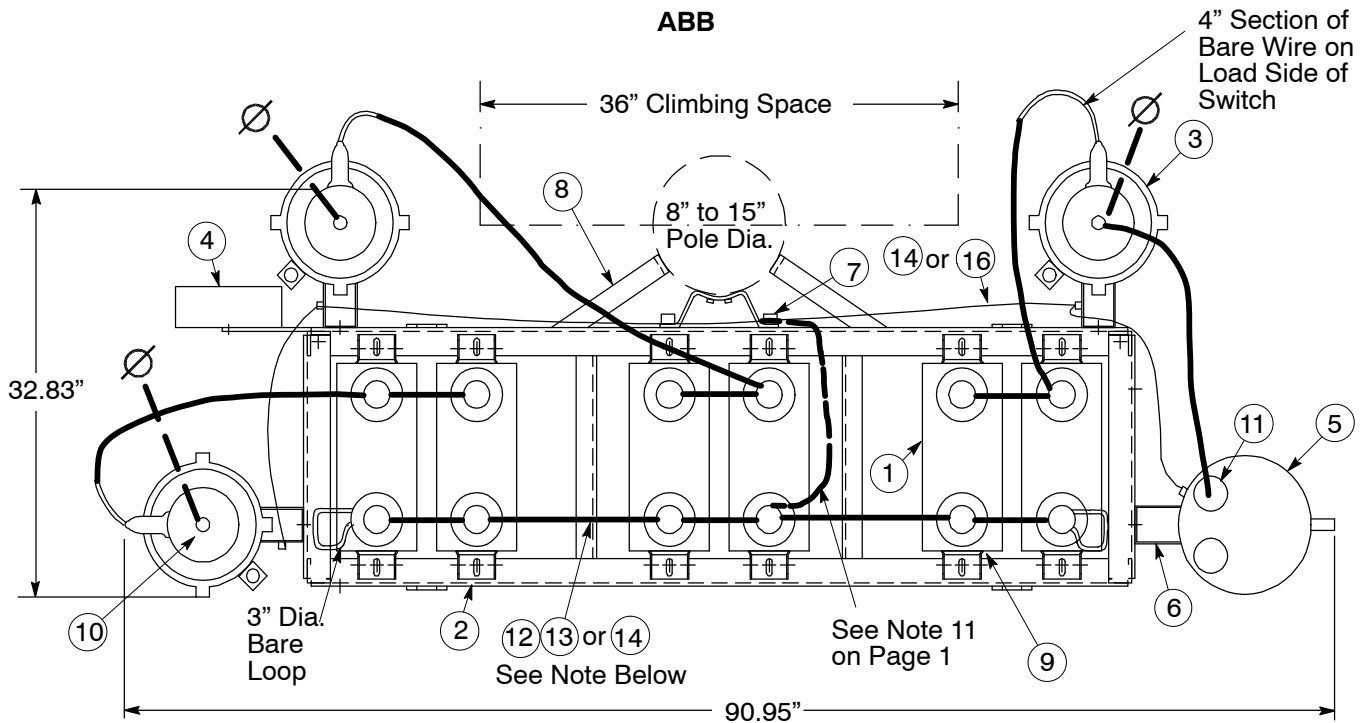
Note - This wire may be bent down for shipment. Bend it back up before energizing.

Switched, Wye Connected, 6-Capacitor Unit Banks

17 kV
1,200 kvar – Code 266341
21 kV
1,200 kvar – Code 266308
1,800 kvar – Code 266309



ABB

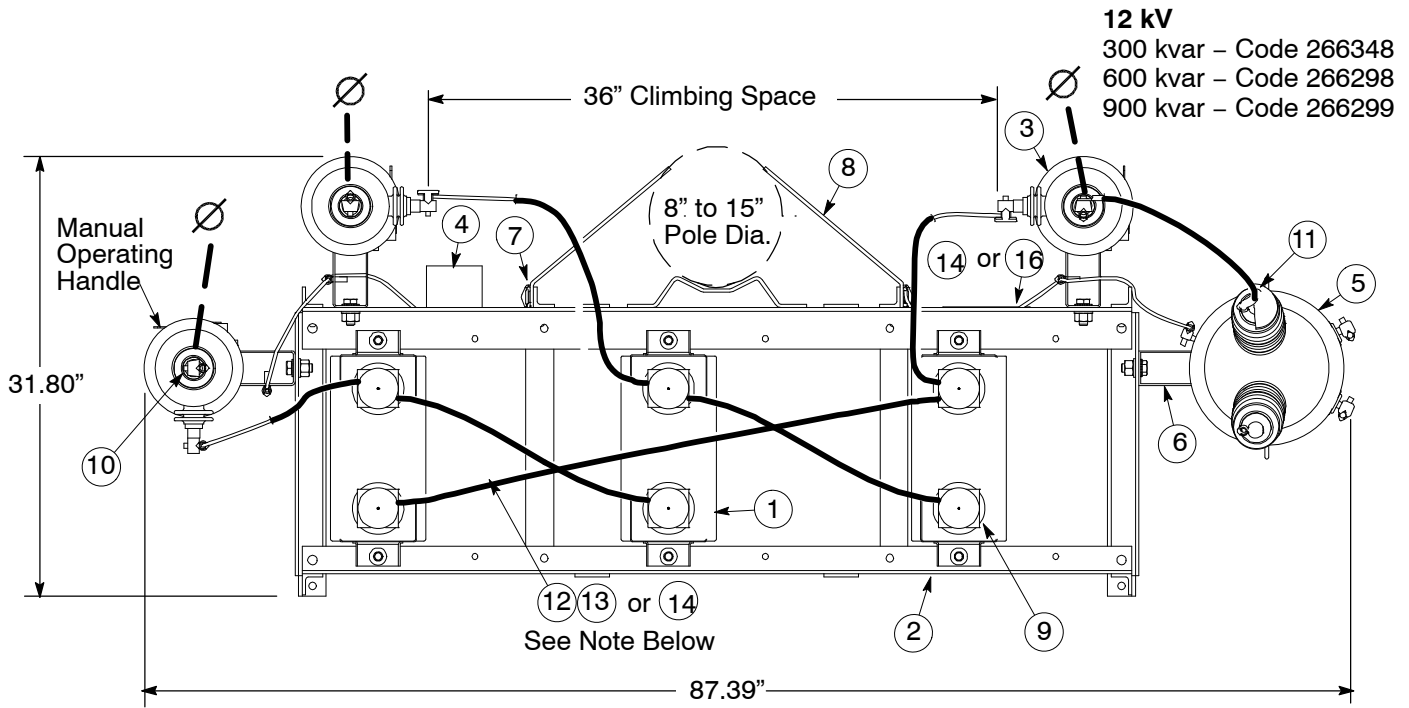


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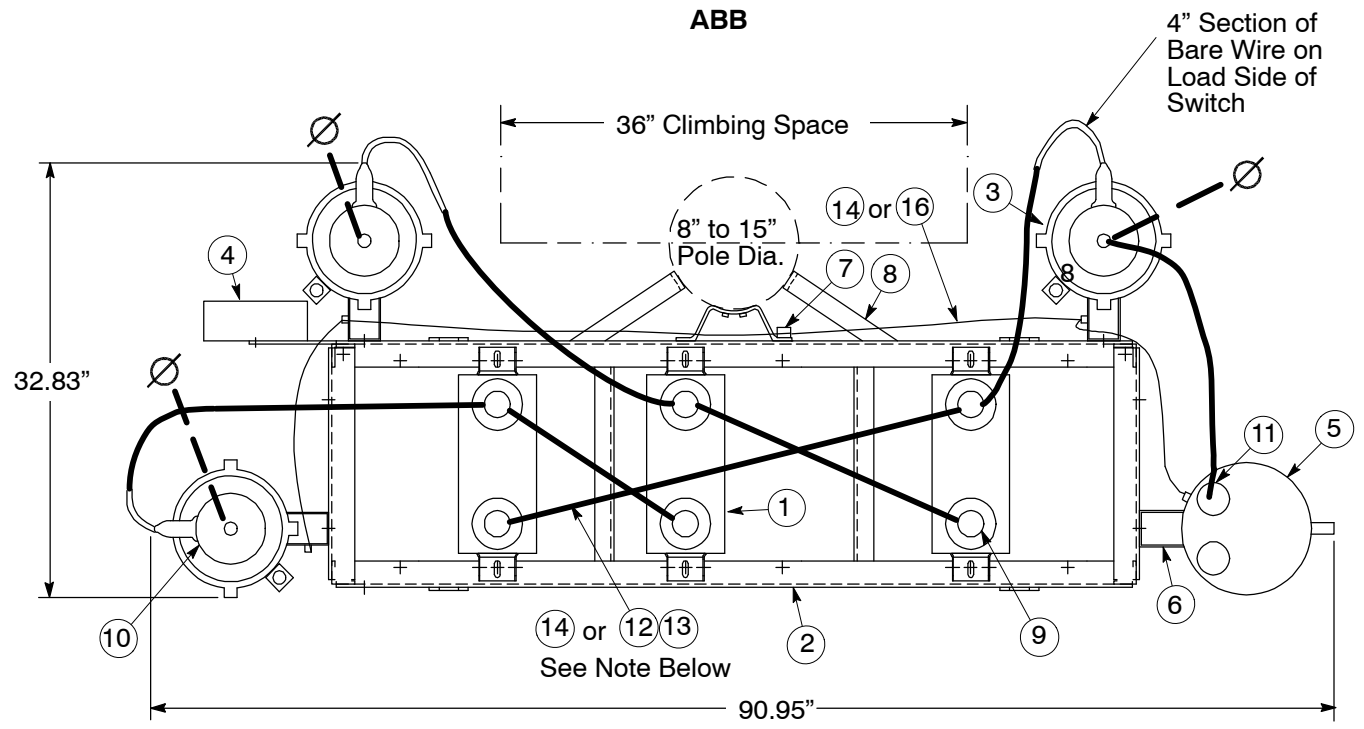
Figure 3
Switched 6-Unit Wye

Note - This wire may be bent down for shipment. Bend it back up before energizing.

Switched, Delta Connected, 3-Capacitor Unit Banks



ABB



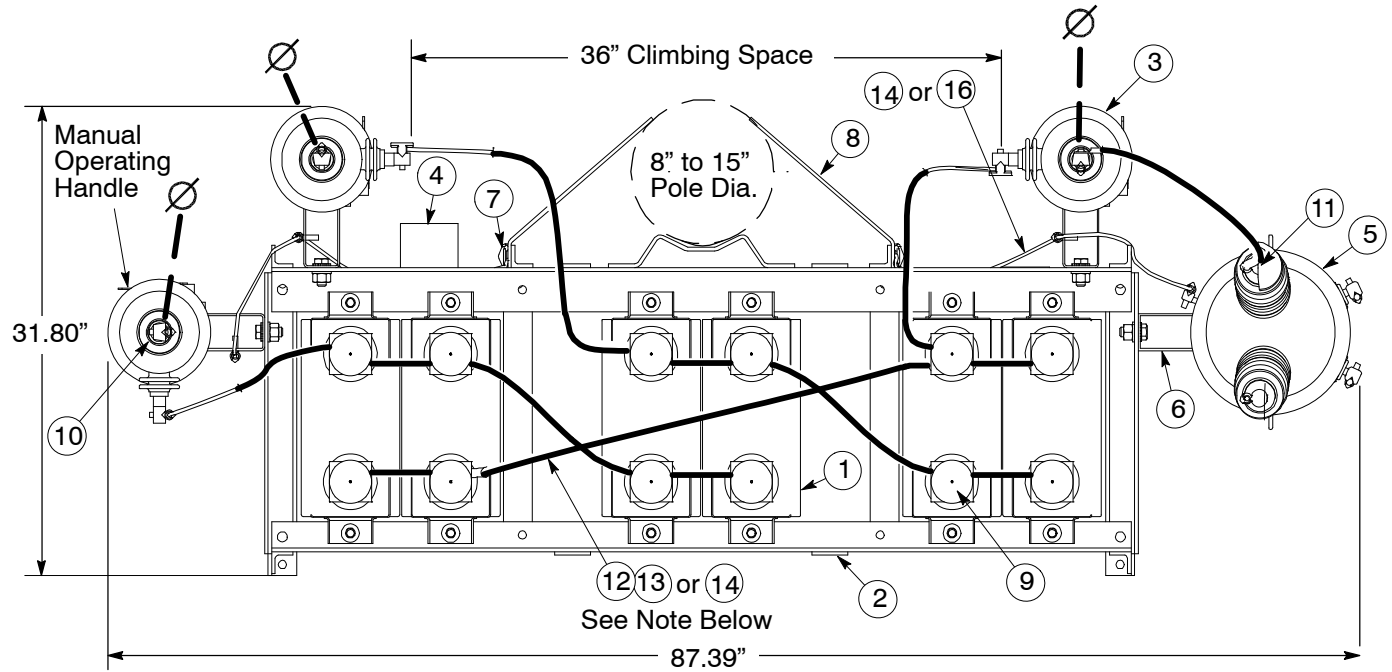
Cooper

Figure 4
Switched 3-Unit Delta

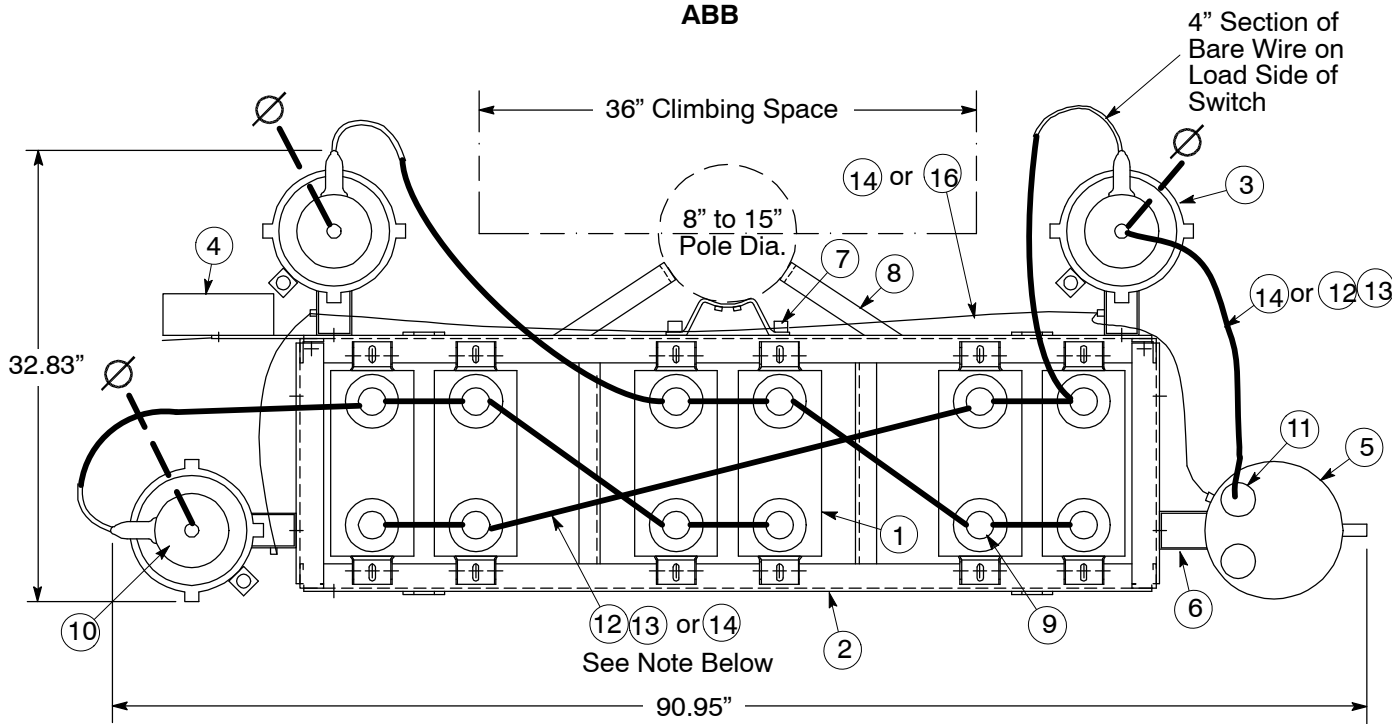
Note - This wire may be bent down for shipment. Bend it back up before energizing.

Switched, Delta Connected, 6-Capacitor Unit Banks

12 kV
1,200 kvar Code 266300



ABB



Cooper

Figure 5
Switched 6-Unit Delta

Note - This wire may be bent down for shipment. Bend it back up before energizing.

SWITCH CONTROL CONNECTIONS

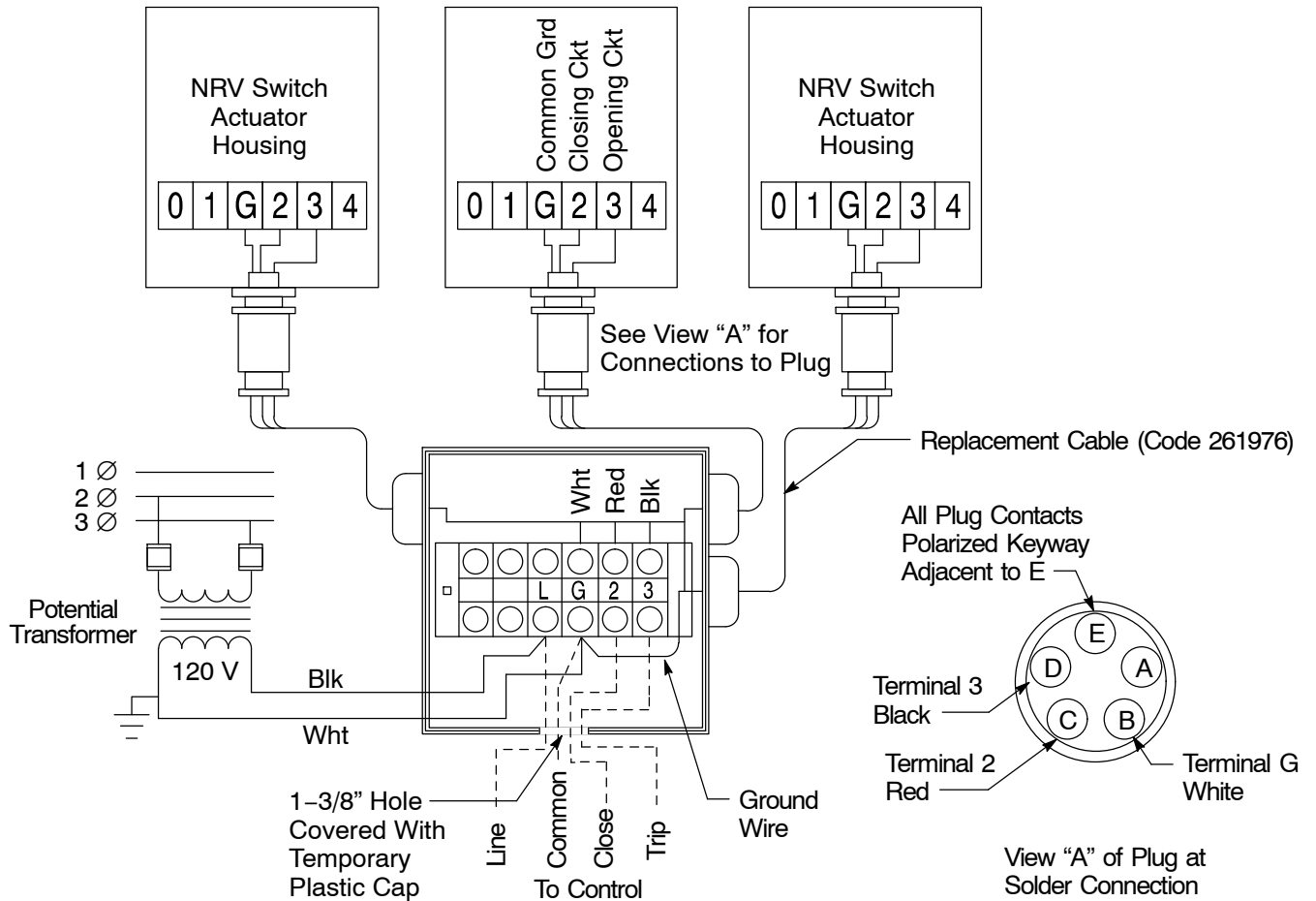


Figure 6
Cooper Switch Control Circuit Connections

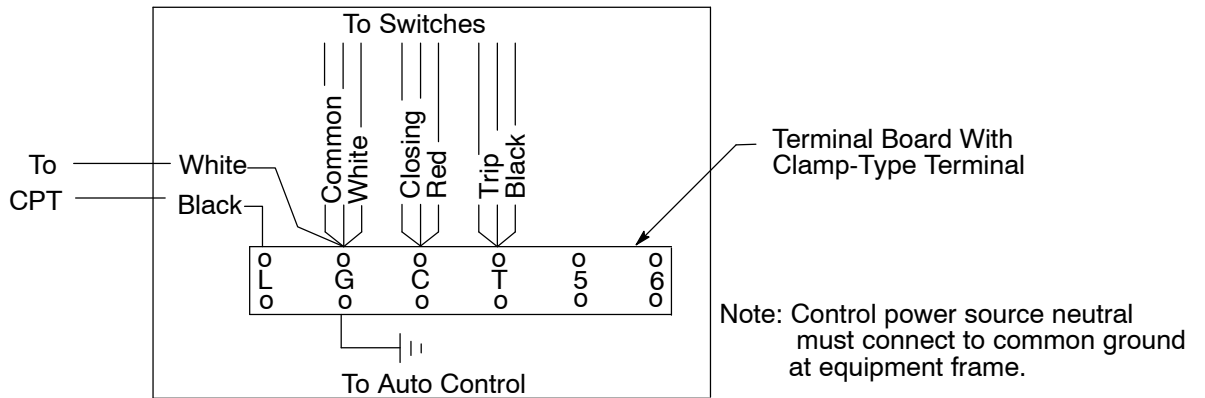
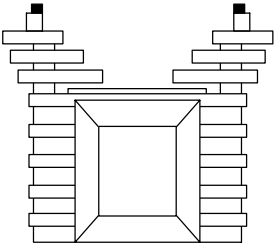
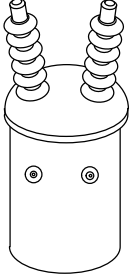


Figure 7
ABB and General Electric Control Circuit

Table 6 Translation Box

ABB / GE	Cooper
L	L
G	G
C	2
T	3

Table 7 Replacement Potential Transformers

Description	4 kV	12 kV	17 kV	21 kV
 Dry Type	250122	253058	250130	016021
 Oil Filled	250121	250048	250051	250049

General Information

1. Application: Oil-filled PTs are for use with switch capacitor banks. (See [Documents 028425](#) and [066197](#)) and SCADA controlled Regulators (See [015239](#)).
2. Oil-filled PTs are to be made of stainless steel.
3. Oil-filled PTs are not interchangeable with dry type PTs due to mounting restrictions.

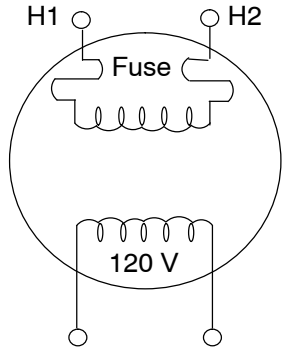


Figure 8
Oil-Filled PT Wiring Diagram

Table 8 Transformer Components

Item	Components
1	Hanger Bracket
2	Lifting Hook
3	High-Voltage Bushing
4	Low-Voltage Bushing
5	Nameplate
6	Pressure-Relief Valve
7	Tank Ground Pad
8	Animal Guard

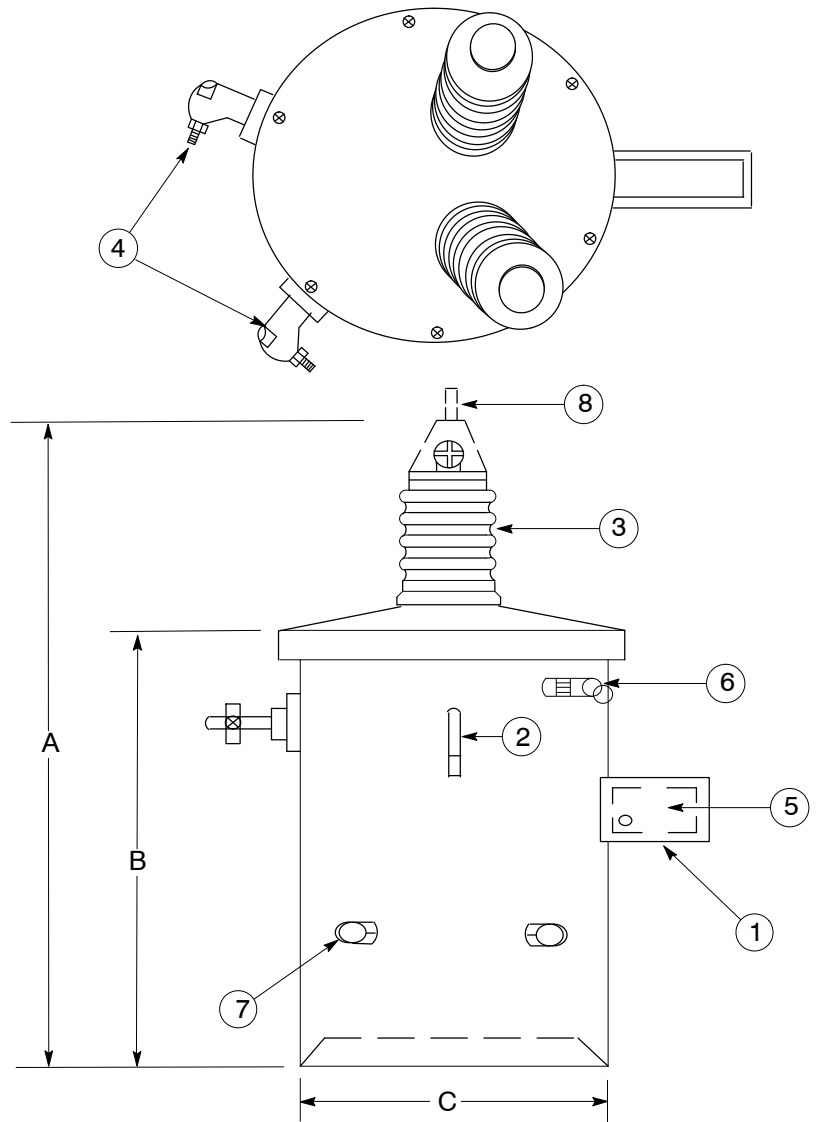


Figure 9
Oil-Filled PT

Table 9 Typical Dimensions

Voltage	Dimensions (inches)		
	A	B	C
4,160	25-27	15.5-16.5	9-10
12,000			
17,200			
20,780	25-27		

Vacuum Switches

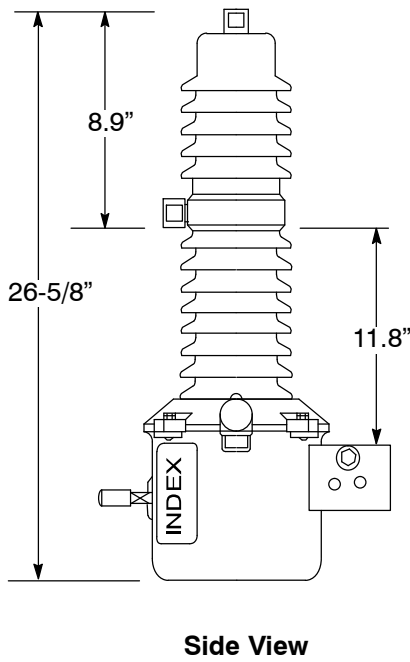
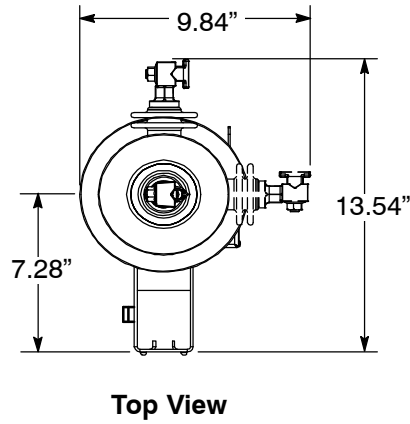
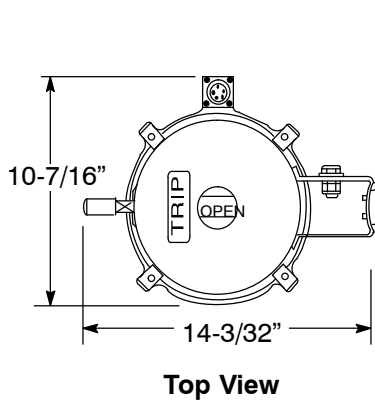


Figure 10
Thomas and Betts
Joslyn Versavac II
Polymer Type
22.5 kV / 125 kV BIL / 200 A
Vacuum Switch
(Code 350973)

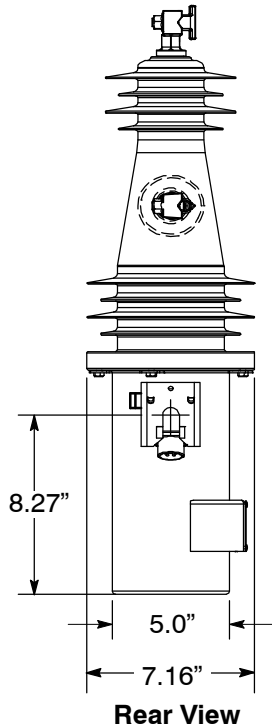
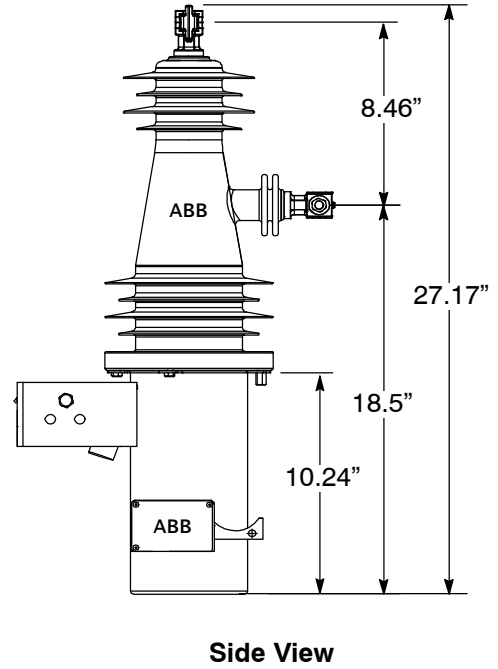


Figure 11
ABB
PS-25 LP
Polymer Type
25 kV / 125 kV BIL / 200 A
Vacuum Switch
(Code 350920)



Note: If cutouts in the open position do not clear the vacuum switches below, the cutout arm may be mounted on the climbing space side of the pole.

Vacuum Switches (continued)

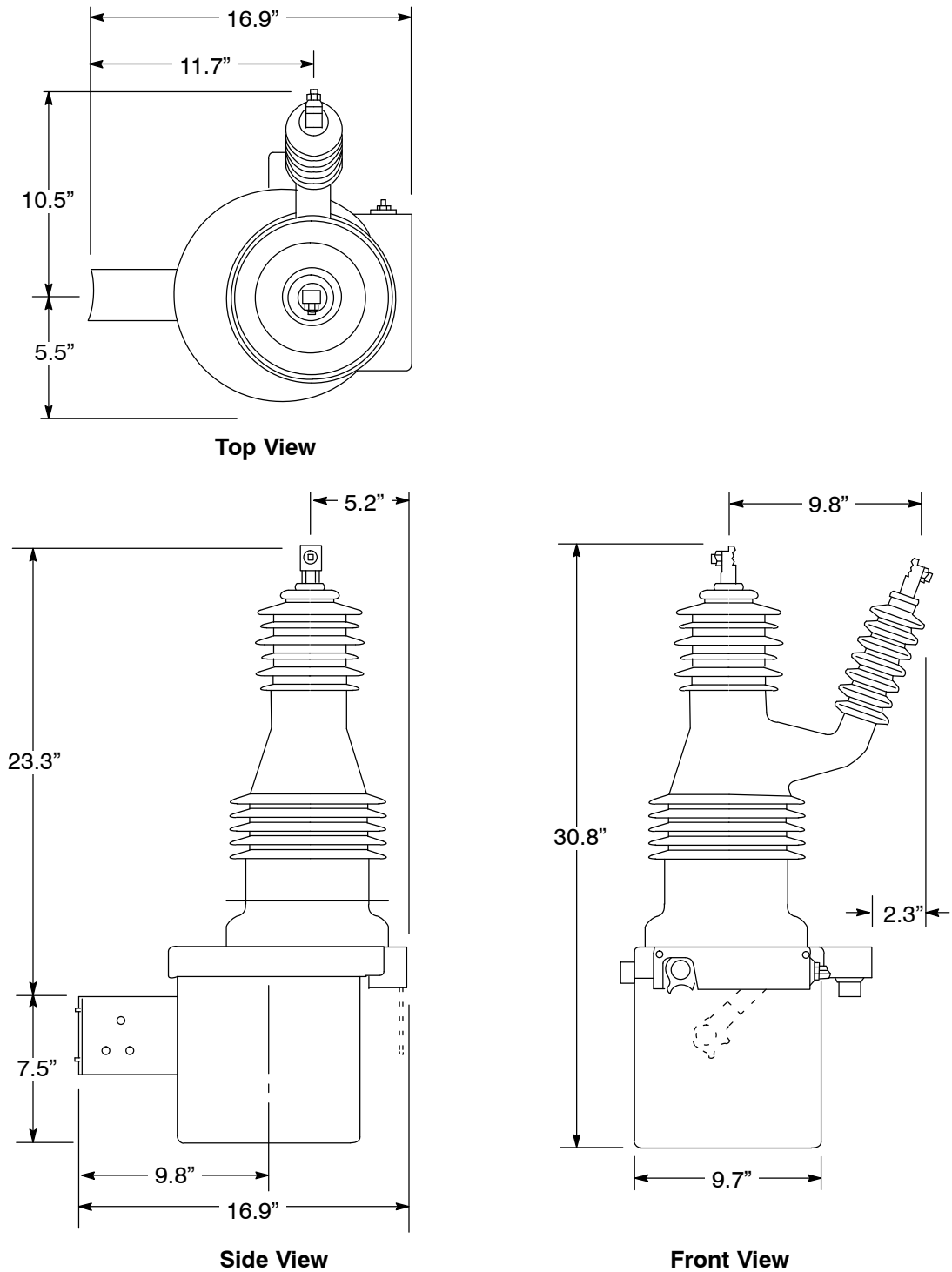


Figure 12
Maysteel
UltraVac 20/150
Polymer Type
24 kV / 150 kV BIL / 150 A max
Vacuum Switch
(Code 350211)

Rotating the Insulator Bushing Without Compromising the Switch

Josylyn Versvac II

1. Do Not Rotate Switch

This will disable the manual trip handle. If a rotated switch is required then contact standards engineering personnel.

ABB PS-25 Vacuum Switch

1. Loosen the four insulator-to-tank mounting bolts three complete turns, and lift and rotate the insulator body to suit the installation.

Notes:

1. **Do Note Completely Remove the Locating Bolt.** This is to prevent over-rotation which can pull the internal wiring out.
2. One of the four mounting bolts (the "locating" bolt) has an extended bolt head that will prevent the housing turning more than 170 degrees each way.
2. After re-orienting the terminals, immediately re-torque the insulator-to-tank mounting bolts in an alternating pattern to 120 in-lb. or 10 ft-lb.

Note: Failure to tighten insulator-to-tank mounting fasteners can result in equipment damage.

Maysteel Vacuum Switch

1. Loosen the four hex bolts that secure the tank clamps until they are loose, but the clamps are still held in place.
2. Once the clamps are loose, move the bushing/casting back and forth slightly to loosen the hold of o-ring seal to the tank lip (there is a film of silicone grease on the tank lip).
3. When the casting moves easily, rotate the upper assembly to the orientation desired, keeping the manual handle/indicator and connector away from the mounting bracket to avoid interference during operation.
4. After the desired orientation is achieved, tighten the clamp bolts using a torque of 140 to 150 in-lb. or 14 or 15 ft-lb.

Capacitors for Distribution Lines

Single-Phase Primary Capacitor Units, Non-PCB, All Film

Note

1. All capacitors have NEMA standard mounting dimensions (15-5/8").

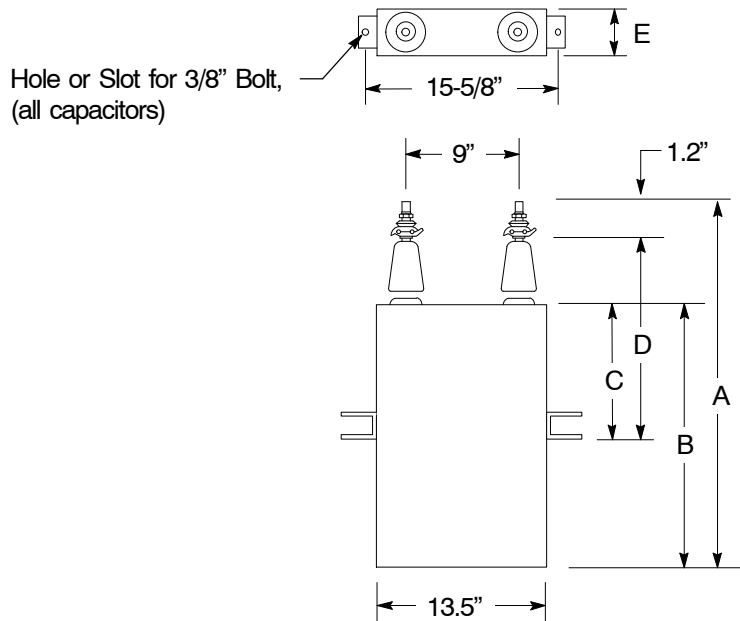


Figure 13
Primary Single-Phase Capacitors

Table 10 Single-Phase Primary Capacitor Units (ABB)

Rating		Code	BIL	Approximate Dimensions in Inches					Approximate Weight (lbs.)
Volts	kvar			A	B	C	D	E	
2,400	50	266332	95	16.86	7.36	6.89	15.29	5.43	39
	100	266330	95	17.26	7.76	6.89	15.29	5.43	40
9,960	200	266287	125	24.7	12.09	6.89	18.4	5.43	60
	300	266331	125	29.03	16.42	6.89	18.4	5.43	76
12,000	100	266354	125	20.37	7.76	6.89	18.4	5.43	43
	200	266322	125	24.7	12.09	6.89	18.4	5.43	60
	300	266350	125	29.03	16.42	6.89	18.4	5.43	76

Table 11 Single-Phase Primary Capacitor Units (Cooper)¹

Rating		Code	BIL	Approximate Dimensions in Inches					Approximate Weight (lbs.)
Volts	kvar ²			A	B	C	D	E	
2,400	50 ³	266332	95	14.25	6.0	5.9	12.9	4.0	25
	100	266330	95	14.75	6.5	5.9	12.9	4.75	30
9,960	200	266287	125	22.9	11.0	5.9	16.6	5.0	46
	300	266331	125	26.9	15.0	9.9	20.6	5.0	60
12,000	100	266354	125	18.9	7.0	5.9	16.6	4.75	31
	200	266322	125	23.4	11.5	5.9	16.6	4.5	44
	300	266350	125	26.9	15.0	9.9	20.6	5.0	60

¹ Data is for Cooper capacitor units purchased beginning in 2011.

² All capacitors have NEMA standard mounting dimensions (15-5/8").

³ For series capacitor banks only.

Single-Phase Primary Capacitor Units, Non-PCB, All Film (continued)

Table 12 Single-Phase Primary Capacitor Units (General Electric) ¹

Rating		Code	BIL	Approximate Dimensions in Inches					Approximate Weight (lbs.)
Volts	kvar			A	B	C	D	E	
2,400	50	266332	75	14.8	5.25	3.0	11.0	5	40
	100	266330	75	17.8	8.25	7.5	15.5	4.6	60
9,960	200	266287	125	22.8	12.25	6.0	15.25	5.1	90
	300	266331	125	27.8	17.25	7.5	16.75	4.6	120
12,000	100	266354	125	18.8	8.25	7.5	16.75	4.6	60
	200	266322	125	22.8	12.25	6.0	15.25	4.9	90
	300	266350	125	27.8	17.25	7.5	16.75	4.6	120

¹ Data is for General Electric capacitor units purchased beginning in 2003.

Table 13 Single-Phase Primary Capacitor Units – Cooper 1997–1999

Rating		Code	BIL	Approximate Dimensions in Inches					Approximate Weight (lbs.)
Volts	kvar ¹			A	B	C	D	E	
2,400	50 ²	266332	75	14.25	6.0	5.9	12.9	4.0	40
	100	266330	75	15.75	7.5	5.9	12.9	4.25	60
9,960	200	266287	125	25.4	13.5	9.9	20.6	4.5	90
	300	266331	125	31.4	19.5	9.9	20.6	4.0	120
12,000	100	266354	125	20.1	8.25	5.9	16.6	4.0	60
	200	266322	125	25.4	13.5	9.9	20.6	4.5	90
	300	266350	125	31.4	19.5	9.9	20.6	4.0	120

¹ All capacitors have NEMA standard mounting dimensions (15-5/8").

² For series capacitor banks only.

Table 14 Acceptable Capacitance Ranges for Testing Capacitor Units

Nameplate Rating		Acceptable Meter Reading Range Capacitance in Microfarads ^{1, 2} Phase-to-Phase
Voltage	kvar (1-phase)	
2,400	50	23.0–26.5
2,400	100	46.1–53.0
7,200	100	5.12–5.89
7,200	200	10.2–11.8
7,200	300	15.4–17.7
9,960	100	2.67–3.08
9,960	200	5.35–6.15
9,960	300	8.02–9.22
12,000	100	1.84–2.12
12,000	200	3.68–4.23
12,000	300	5.53–6.36
Voltage	kvar (3-phase)	Acceptable Meter Reading Range Capacitance in Microfarads Phase-to-Neutral
4,160	300	46.1–53.0
12,470	300	5.12–5.89
17,200	300	2.67–3.08
21,600	300	1.71–1.97

¹ Allowed range is –0% to +15%.

² A digital capacitance meter, including lead set and carrying case, can be purchased using Code 244283.

Revision Notes

Revision 18 has the following changes:

1. Removed reference of "oil" switch. All references should be for capacitor switch.
2. Edited Note 1 on Page 10.