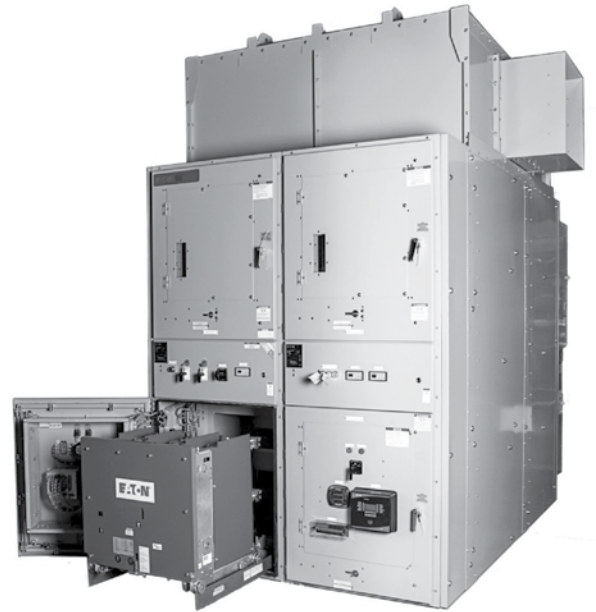


Medium-voltage power distribution and control systems > Switchgear >

VacClad-W 27 kV, arc-resistant metal-clad medium-voltage switchgear

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General Description



**Arc-Resistant Switchgear
with Plenum Installed**

Eaton has been manufacturing arc-resistant metal-clad switchgear since 1990. Eaton was the first major North American manufacturer to design, test and manufacture arc-resistant switchgear in accordance with EEMAC G14.1. We now offer Type 2 and 2B arc-resistant switchgear assemblies, designed and tested in accordance with the IEEE® C37.20.7, with Type VCP-W drawout vacuum circuit breakers.

Eaton's VacClad-W metal-clad arc-resistant switchgear with Type VCP-W vacuum circuit breakers can be configured in various combinations of breakers and auxiliaries to satisfy user's application requirements. One-high and two-high arrangements can be provided when required.

Arc-Resistant Switchgear— Accessibility Types

Arc-resistant switchgear performance is defined by its accessibility type in accordance with IEEE test guide C37.20.7 as follows:

Type 1—Switchgear with arc-resistant designs or features at the freely accessible front of the equipment only.

Type 2—Switchgear with arc-resistant designs or features at the freely accessible exterior (front, back and sides) of the equipment only. (Type 2 incorporates Type 1.)

Type 2B—Switchgear with Type 2 accessibility plus arc-resistant in front of the instrument/control compartment with the instrument/control compartment door opened. (Type 2B incorporates Type 2.)

Eaton's 27 kV switchgear is designed and tested for IEEE Type 2 accessibility.

Arc-resistant features are intended to provide an additional degree of protection to the personnel performing normal operating duties in close proximity to the equipment while the equipment is operating under normal conditions. The normal operating conditions for proper application of arc-resistant switchgear designs are as follows:

- All doors and covers providing access to high-voltage components are properly closed and latched
- Pressure relief devices are free to operate
- The fault energy available to the equipment does not exceed the rating of the equipment (short-circuit current and duration)
- There are no obstructions around the equipment that could direct the arc fault products into an area intended to be protected
- The equipment is properly grounded

The user should also refer to documents such as NFPA 70E, for safety training and safe work practices and methods of evaluating safe work distances from energized equipment based on the potential flash hazard, and use proper PPE when working on or near energized equipment with the door/cover opened or not properly secured.

Standards

Switchgear Assembly

Eaton's VacClad-W metal-clad arc-resistant switchgear meets or exceeds the following standards and test guides:

North American Documents

- IEEE C37.20.2—Standards for Metal-Clad Switchgear
- IEEE C37.20.7—Guide for Testing Metal-Enclosed Switchgear for Internal Arcing Faults

Canadian Documents

- CSA® C22.2 No. 31-04—Switchgear Assemblies
- EEMAC G8-3.2—Metal-Clad and Station Type Cubicle Switchgear
- EEMAC G14-1—Procedure for testing the resistance of metal-clad switchgear under conditions of arcing due to an internal fault. The G14-1 was the first North American testing guide introduced in 1987

Circuit Breakers

The Type VCP-W and VCP-WC vacuum circuit breakers, used in VacClad-W arc-resistant switchgear, meet or exceed all ANSI and IEEE standards applicable to ac high-voltage circuit breakers rated on symmetrical current basis, including but not limited to: C37.04, C37.06, and C37.09. Also available are type VCP-WG vacuum circuit breakers conforming to IEEE standard C37.013 for ac high-voltage generator circuit breakers.

Arc-Resistant Metal-Clad Switchgear

Arc-resistant metal-clad switchgear also conforms to C37.20.2 and is tested as such for short time and momentary short-circuit withstand for through bolted fault. In addition, the enclosure is also tested in accordance with IEEE guide C37.20.7 for withstand against the effects of internal arcing faults as shown in **Figure 5.5-1**.

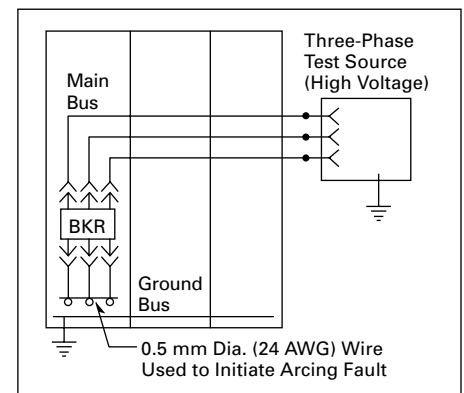


Figure 5.5-1. Arc-Resistant Switchgear Enclosure Internal Arcing Short-Circuit Withstand Test

Internal arcing faults are those faults occurring in air, phase-to-phase or phase-to-ground, within the confines of the switchgear enclosure. Arcing faults can occur within a switchgear compartment as a result of insulation failure or human error. The arcing fault produces a tremendous release of heat energy at the point of the fault, which heats and expands the air volume within the enclosure, and may decompose or vaporize materials exposed to an arc or involved in its path.

The effects of this type of fault vary depending on enclosure volume, arc duration, arc voltage, and available short-circuit current. If the switchgear is not designed and tested to withstand effects of internal arcing faults, its parts could blow away along with discharge of hot decomposed matter, gaseous or particulate, causing injury to personnel that may be present in its vicinity. Arc-resistant switchgear is designed to channel and control effects of the arcing fault and its enclosure is tested for withstand against such fault in accordance with IEEE guide C37.20.7.

Medium-Voltage Vacuum Circuit Breaker Features and Ratings

VacClad-W metal-clad arc-resistant switchgear is designed for use with Eaton's state-of-the-art medium-voltage vacuum type VCP-W (standard ANSI) and VCP-WC (extra capability) circuit breakers. Refer to **Table 5.5-7** for complete list of available ratings.

Arc-Resistant Enclosure and Arc Exhaust

VacClad-W arc-resistant switchgear is designed to withstand effects of internal arcing faults up to its rated arc short-circuit current and duration. The arc-withstand capability of the switchgear enclosure is achieved by use of reinforced heavier gauge steel where needed, smart latching of doors and covers, and top-mounted built-in pressure relief system. Following are standard design features built into each arc-resistant switchgear assembly.

- The formed steel compartment design provides sealed joints under fault conditions. This prevents smoke and gas from escaping to other compartments, a condition that can occur with switchgear compartments designed with conventional flat bolted panels
- Integral, pressure release flap vents mounted on top of each individual vertical section provide for controlled upward release of arc created over-pressure, fire, smoke, gases and molten material out of the assembly without affecting structural integrity, and protect personnel who might be present in the vicinity of the switchgear
- The structure roof, including the pressure release flap vents, is drip proof. The design is made strong such that the roof can be "walked-on" when the gear is completely de-energized (for example, during installation)
- Because arc pressure is vented out through the top of each individual vertical section, the equipment damage is confined to individual structures, minimizing damage to adjacent structures

Circuit Breaker Compartment

- The levering mechanism is mechanically interlocked with the compartment door such that the door cannot be opened until the circuit breaker is opened and levered out to the test/disconnect position. This interlocking ensures that the levering of the circuit breaker into or out from the connected position is done with compartment door closed and latched, with no exposure to potential arc flash
- Easy access and viewing ports are provided on the door to allow operator to carry out normal functions with the door closed and latched, with no exposure to potential arc flash. Those functions include: Breaker levering and manual opening of the circuit breaker, viewing of open/close status of the breaker main contacts, viewing of charged/discharged status of the closing springs, viewing of mechanical operations counter, and breaker position

Auxiliary Compartments

The 27 kV design permits maximum of only one auxiliary drawer per vertical section.

- Each auxiliary drawer is equipped with cell-mounted levering mechanism. The mechanism is mechanically interlocked with its compartment door such that the door cannot be opened and access to auxiliary drawer cannot be gained until the drawer is first levered out to the disconnected position. This interlocking ensures that the levering of the auxiliary drawer into or out from the connected position is done with compartment door closed and latched, with no exposure to potential arc flash
- A viewing window is provided on the door and on front panel of the drawer to allow viewing of the drawer position and the primary fuses
- In 27 kV designs, an auxiliary drawer can be configured as a fuse drawer with two primary fuses and connected to a fixed-mounted CPT (single-phase 25 kVA maximum) in the rear of the structure

Control Compartments

The control compartment doors can be opened to access control wiring without having to de-energize the primary circuit. The control compartments have been tested to provide arc-resistant protection with its door opened under normal operating condition. Please note the control compartment door should be opened only for access to control wiring when needed, and should remain closed at all other times.

27 kV Arc-Resistant Switchgear



*Front View—27 kV VCP-W Arc-Resistant Switchgear
(Plenum Above the Switchgear is Not Shown)*



*Typical 27 kV Cell—Controls in Top,
Breaker in the Bottom*



*Rear View—Typical 27 kV
Breaker Cable Termination*

Note: Application layouts and dimensions—refer to **Page 5.5-19** to **Page 5.5-22**.

Standard Metal-Clad Switchgear Assembly Ratings

VacClad-W metal-clad arc-resistant switchgear is available for application at voltages up to 38 kV, 50 or 60 Hz. Refer to the table below for complete list of available ratings.

Table 5.5-1. VacClad-W Arc-Resistant Metal-Clad Switchgear

Rated Maximum Voltage	(Ref.) Rated Voltage Range Factor K	(Ref.) Rated Short-Circuit Current I	Ratings per IEEE C37.20.2-2015						Enclosure Internal Arc Withstand				
			Insulation Level		Rated Main Bus Continuous Current	Rated Short-Time Short-Circuit Current Withstand (2-Second)	Rated Momentary Short-Circuit Current Withstand (10-Cycle) (167 ms)		Accessibility Type		Rated Arc Short-Circuit Withstand Current		Rated Arc Duration
			Power Frequency Withstand Voltage, 60 Hz, 1 Minute	Lightning Impulse Withstand Voltage [LIWV] (BIL)			K*I	2.7 *K*	1.6 *K* I (Ref. only)	IEEE C37.20.7	EEMAC G14-1	Isc	
kV rms		kA rms	kV rms	kV Peak	Amperes	kA rms Sym.	kA Crest	kA rms Asym.			kA rms Sym.	kA Peak	Sec.
27 ①②	1	16	60	125	1200, 2000, 2500, 3000	16	43	26	2	B	16	41.6	0.5
	1	22				22	60	35	2	B	22	57.2	0.5
	1	25				25	68	40	2	B	25	65	0.5
	1	31.5				31.5	85	51	2	B	31.5	81.9	0.5
	1	40				40	108	64	2	B	40	104	0.5

① 27–38 kV switchgear is supplied with arc wall. For plenum requirements at 27 and 38 kV, contact Eaton.

② 27 kV arc-resistant switchgear can be supplied in one-high configuration only.

Unusual and Usual Service Conditions

Unusual Service Conditions

Applications of metal-clad switchgear at other than usual altitude or temperature, or where solar radiation is significant, require special consideration. Other unusual service conditions that may affect design and application include:

- Exposure to salt air, hot or humid climate, excessive dust, dripping water, falling dirt, or other similar conditions
- Unusual transportation or storage conditions
- Switchgear assemblies when used as the service disconnecting means
- Installations accessible to the general public
- Exposure to seismic shock
- Exposure to nuclear radiation

Usual Service Conditions

Usual service conditions for operation of metal-clad switchgear are as follows:

- Altitude does not exceed 3300 feet (1000 m)
- Ambient temperature within the limits of -30 °C and +40 °C (-22 °F and +104 °F)
- The effect of solar radiation is not significant

Applications Above 3300 Feet (1006 m)

Equipment utilizing sealed interrupting devices (such as vacuum interrupters) does not require derating of rated maximum voltage. The rated one-minute power frequency withstand voltage, the impulse withstand voltage and the continuous current rating must be multiplied by the appropriate correction factor in **Table 5.5-4** to obtain modified ratings that must equal or exceed the application requirements.

Note: Intermediate values may be obtained by interpolation.

Applications Above or Below 40 °C Ambient

Refer to ANSI C37.20.2, Section 8.4 for load current-carrying capabilities under various conditions of ambient temperature and load.

Applications at Frequencies Less Than 60 Hz

Rated Short-Circuit Current

Based on series of actual tests performed on Type VCP-W circuit breakers and analysis of these test data and physics of vacuum interrupters, it has been found that the current interruption limit for Type VCP-W circuit breakers is proportional to the square root of the frequency. **Table 5.5-2** provides derating factors, which must be applied to breaker interrupting current at various frequencies.

Table 5.5-2. Derating Factors

Interrupting Current Derating Factors			
50 Hz	25 Hz	16 Hz	12 Hz
None	0.65	0.52	0.45

Rated Short-Time and Close and Latch Currents

No derating is required for short time and close and latch current at lower frequency.

Rated Continuous Current

Because the effective resistance of circuit conductors is less at lower frequency, continuous current through the circuit can be increased somewhat. **Table 5.5-3** provides nominal current rating for VCP-W breakers when operated at frequencies below 60 Hz.

Table 5.5-3. Current Ratings

Rated Continuous Current at 60 Hz	Nominal Current at Frequency Below 60 Hz			
	50 Hz	25 Hz	16 Hz	12 Hz
1200 A	1243	1410	1519	1589
2000 A	2075	2374	2573	2703
3000 A	3119	3597	3923	4139

Power Frequency and Impulse Withstand Voltage Ratings

No derating is required for lower frequency.

CTs, VTs, Relays and Instruments

Application at frequency other than rated frequency must be verified for each device on an individual basis.

Table 5.5-4. Altitude Derating Factors

Altitude Above Sea Level in Feet (m)	Altitude Correction Factor to be Applied to:	
	Voltage	Rated Continuous Current
3300 (1006) (and Below)	1.0	1.0
4000 (1219)	0.98	0.995
5000 (1524)	0.95	0.991
6000 (1829)	0.92	0.987
6600 (2012)	0.91	0.985
7000 (2137)	0.89	0.98
8000 (2438)	0.86	0.97
9000 (2743)	0.83	0.965
10,000 (3048)	0.80	0.96
12,000 (3658)	0.75	0.95
13,200 (4023)	0.72	0.94
14,000 (4267)	0.70	0.935
16,000 (4877)	0.65	0.925
16,400 (5000)	0.64	0.92
18,000 (5486)	0.61	0.91
20,000 (6096)	0.56	0.90

Unusual Service Conditions

Applications of metal-clad switchgear at other than usual altitude or temperature, or where solar radiation is significant, require special consideration. Other unusual service conditions that may affect design and application include:

- Exposure to salt air, hot or humid climate, excessive dust, dripping water, falling dirt, or other similar conditions
- Unusual transportation or storage conditions
- Switchgear assemblies when used as the service disconnecting means
- Installations accessible to the general public
- Exposure to seismic shock
- Exposure to nuclear radiation

Circuit Breakers

Table 5.5-5. Available 27 kV VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards ①②③

Identification			Rated Values											Related Required Capabilities						Asymmetry Factor for VCP-W Breakers ⑩
Circuit Breaker Type	Nominal Voltage Class	Nominal 3-Phase MVA Class	Voltage		Insulation Level		Current		Rated Transient Recovery Voltage			Rated Permissible Tripping Delay	Rated Reclosing Time	Rated Maximum Voltage Divided by K	Current Values					
			Rated Maximum Voltage	Rated Voltage Range Factor	Power Frequency Withstand Voltage (1 min.)	Lightning Impulse Withstand Voltage (1.2 x 50 μs)	Rated Continuous Current at 60 Hz	Rated Short-Circuit Current (at Rated Maximum kV)	Rated Crest Voltage	Rated Time to Crest	Rate of Rise of Recovery Voltage ⑤				Rated Interrupting Time	Maximum Sym. Interrupting Capability	3-Second Short-Time Current Carrying Capability	Closing and Latching Capability (Momentary) ⑨		
	kV Class	MVA Class	V kV rms	K ④	kV rms	kV Crest	Amp	I ④ kA rms	E2 kV Crest	T2 μS	kV/μS	⑥ Cycles	Y ⑦ Sec.	⑧ ms	V/K kV rms	KI kA rms	KI kA rms	2.7 K Times Rated Short-Circuit Current ④	2.7 K Times Rated Short-Circuit Current	
270VCP-W 16	27	750	27	1.0	60	125	1200 2000	16	51	105	0.55	5	2	300	27	16	16	43	26	1.2
270VCP-W 22	27	1000	27	1.0	60	125	1200 2000	22	51	105	0.55	5	2	300	27	22	22	60	35	1.2
270VCP-W 25	27	1250	27	1.0	60	125	1200 2000	25	51	105	0.55	5	2	300	27	25	25	68	40	1.2
270VCP-W 32	—	1600	27	1.0	60	125	1200 2000	31.5	51	105	0.55	5	2	300	27	31.5	31.5	85	51	1.2
270VCP-W 40	27	2000	27	1.0	60	125	1200 2000	40	51	105	0.55	5	2	300	27	40	40	108	64	1.2

① For capacitor switching, refer to Table 5.5-7.

② 27 kV breakers are not UL listed.

③ Circuit breakers shown in this table were tested in accordance with IEEE standard C37.09-1979.

④ For three-phase and line-to-line faults, the symmetrical interrupting capability at an operating voltage

$$I_{sc} = \frac{V}{V_o} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

Single line-to-ground fault capability at an operating voltage

$$I_{sc} = 1.15 \frac{V}{V_o} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

The above apply on predominately inductive or resistive three-phase circuits with normal-frequency line-to-line recovery voltage equal to the operating voltage.

⑤ $RRRV = 1.137 \frac{E_2}{T_2}$

⑥ 3-cycle rating available, refer to Table 5.5-7.

⑦ Tripping may be delayed beyond the rated permissible tripping delay at lower values of current in accordance with the following formula:

$$T \text{ (seconds)} = Y \left(\frac{\text{K Times Rated Short-Circuit Current}}{\text{Short-Circuit Current Through Breaker}} \right)^2$$

The aggregate tripping delay on all operations within any 30-minute period must not exceed the time obtained from the above formula.

⑧ For reclosing service, there is **No derating** necessary for Eaton's VCP-W family of circuit breakers. **R = 100%**. Type VCP-W breaker can perform the O-C-O per ANSI C37.09; O-0.3s-CO-15s-CO per IEC 56; and some VCP-Ws have performed O-0.3s-CO-15s-CO-15s-CO-15s-CO; **all with no derating**. Contact Eaton for special reclosing requirements.

⑨ For higher close and latch ratings, refer to Table 5.5-7.

⑩ Included for reference only.

⑪ Asymmetrical interrupting capability = "S" times symmetrical interrupting capability, both at specified operating voltage.

Type VCP-W Circuit Breaker Operating Times

The closing time (initiation of close signal to contact make) and opening time (initiation of the trip signal to contact break) are shown in Table 5.5-6.

Figure 5.5-2 below shows the sequence of events in the course of circuit interruption, along with applicable VCP-W circuit breaker timings.

Table 5.5-6. Closing Time and Opening Time

Rated Control Voltage	Breaker Rating	Closing Time Milliseconds	Opening Time Milliseconds	
			Standard 5-Cycle Breaker	Optional 3-Cycle Breaker
48V, 125V, 250Vdc	All	45–60	30–45	30–38
120V, 240Vac	All	45–60	—	—
120V or 240Vac capacitor trip	All	—	26–41	26–38
Optional—undervoltage trip release 48V, 125V, 250Vdc	All	—	30–45	30–45

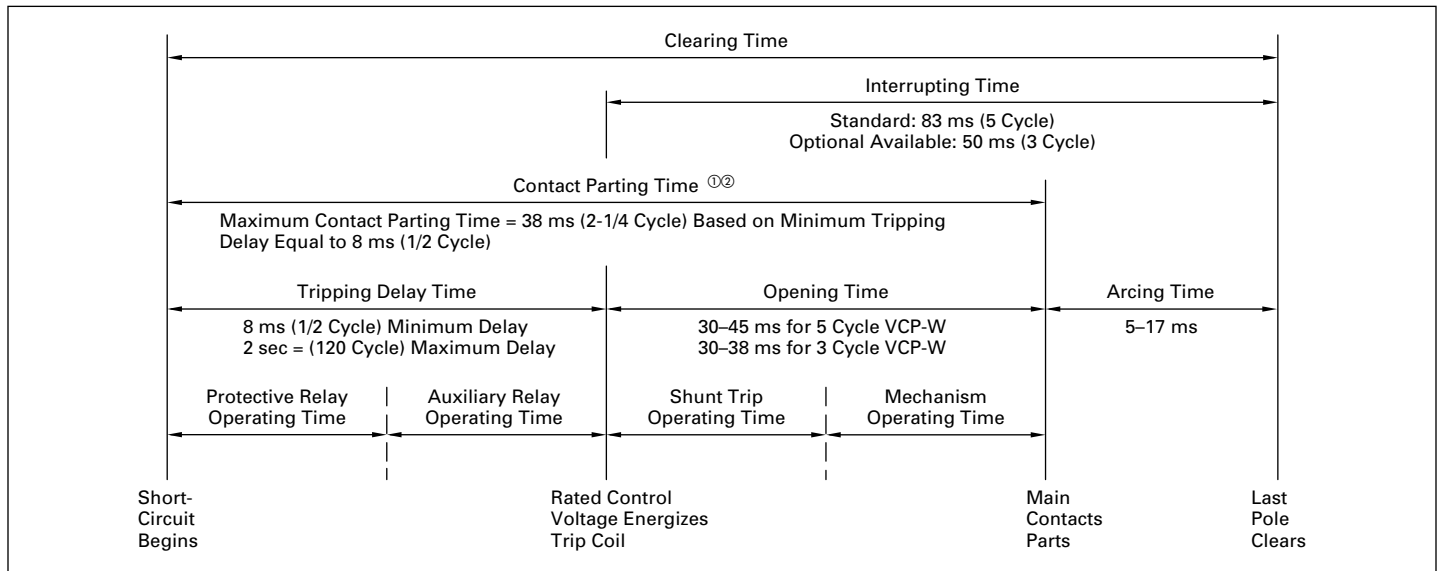


Figure 5.5-2. Sequence of Events and Circuit Breaker Operating Times

- ① Times shown are based on 60 Hz.
- ② % dc component capability (and asymmetry factor S) depend on the minimum contact parting time. The % dc component capability is M 50% (S factor M 1.2) for all VCP-W circuit breakers.

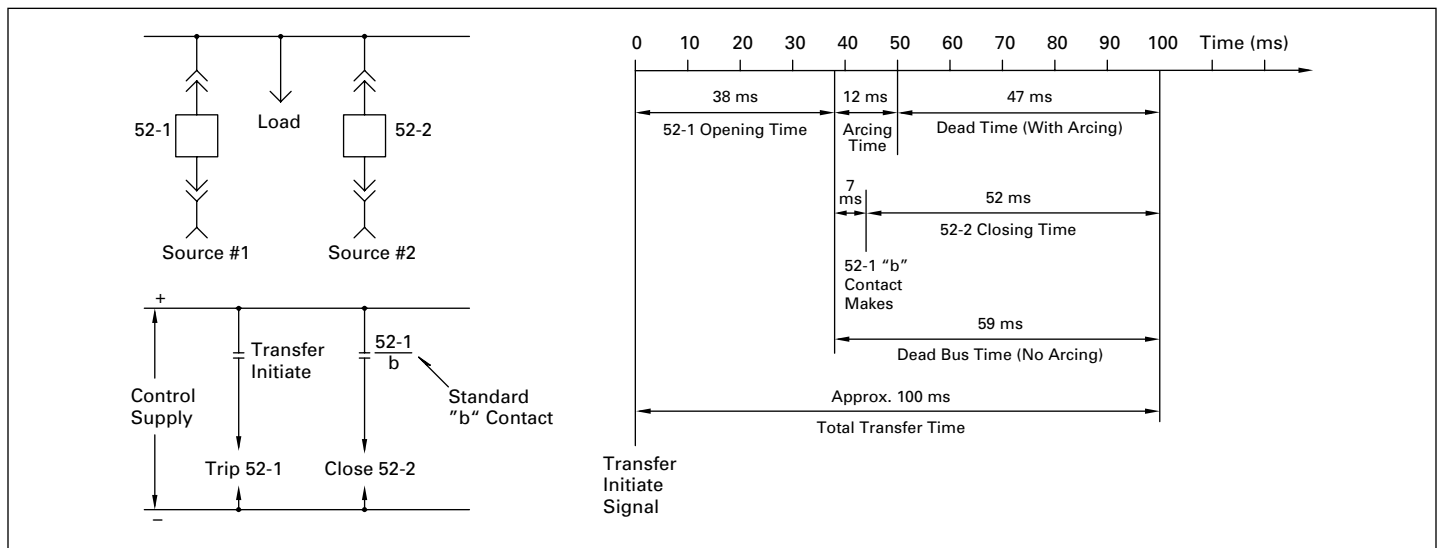


Figure 5.5-3. Typical Transfer Times—Fast Sequential Transfer

- ③ Times shown are based on 60 Hz.

Industry Leader VCP-WC

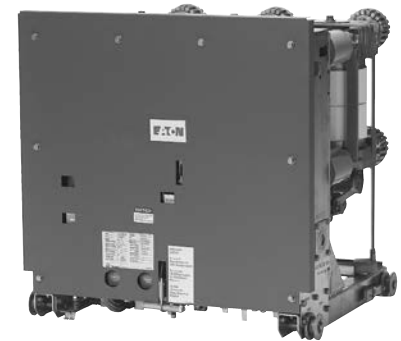
Introducing the VCP-WC extra capability medium-voltage drawout circuit breaker. Designed to provide all the industry-leading features expected of the VCP-W, plus extra capabilities for those application requirements that go beyond what is usually experienced. The performance enhancement features of the VCP-WC make it an ideal choice for capacitor switching duty, high altitude applications, transformer secondary fault protection, locations with concentrations of rotating machinery or high operating endurance requirements, just to mention a few. Consider these capability enhancements:

- Definite purpose capacitor switching
- Higher close and latch
- Faster rate of rise of recovery voltage
- Higher short-circuit current
- Higher mechanical endurance
- Higher insulation level
- Higher voltage ratings with K=1
- 3-cycle interrupting time
- Higher switching life
- Designed and tested to ANSI standards and higher
- WR fixed retrofit configuration available

Vacuum Circuit Breaker Design Leadership

Eaton is a world leader in vacuum interrupter and vacuum circuit breaker technology, offering VCP-WC with extra capabilities without sacrificing the proven features already standard with other VCP-W circuit breakers. Features such as:

- Vacuum interrupters with copper-chrome contacts
- V-Flex non-sliding current transfer system
- Visible contact erosion indicators
- Visible contact wipe indicators
- Front, functionally grouped controls and indicators
- Epoxy insulation (27/38 kV)
- Front, vertically mounted stored energy mechanism
- Drawout on extension rails
- Integrally mounted wheels
- Quality Assurance Certificate



The Type VCP-WC Breakers are not Interchangeable with Standard VCP-W Breakers. They are Equipped with Different Code Plates and Taller Front Panels.

Table 5.5-7. VCP-WC Ratings (Symmetrical Current Basis), Rated K = 1

Identification Circuit Breaker Type	Rated Values															Mechanical Endurance No-Load Operations			
	Voltage		Insulation Level			Current						Maximum Permissible Tripping Delay	Rate of Rise of Recovery Voltage (RRRV) ^③	Capacitor Switching Ratings					
	Maximum Voltage (V)	Voltage Range Factor	Power Frequency Withstand Voltage (1 min.)	Lightning Impulse Withstand Voltage (1.2 x 50 μs)	Continuous Current at 60 Hz	Short-Circuit Current					Interrupting Time ^②			General Purpose			Definite Purpose		
						Sym. Interrupting at Voltage (Isc)	% dc Component (I _{dc})	Asym. Interrupting (I _t)	Closing and Latching Capability	Short-Time Current for 3 Seconds ^①				Cable Charging Current	Isolated Shunt Capacitor Bank Current		Back-to-Back Capacitor Switching		
	kV rms	K	kV rms	kV Peak	A rms	kA rms Total	%	kA rms	kA Peak	kA rms	ms	Seconds	kV/μs				A rms	A rms	A rms
270VCP-W 25C	27	1	60	125	1200 1600	25	75	36	85	25 ^④	50	2.0	1.1	—	400	400	20	4.2	5,000
270VCP-W 32C	27	1	60	125	1200 1600	31.5	55	40	100	31.5 ^⑤	50	2.0	1.1	—	400	400	20	4.2	5,000
270VCP-W 40C	27	1	60	125	1200 1600	40	50	49	112	40 ^⑥	50	2.0	1.1	—	400	400	20	4.2	5,000

① Except as noted.

② 3 cycles.

③ Contact Eaton for higher RRRV or for more information.

④ 2.5 seconds.

⑤ 1.6 second.

⑥ 1 second.

Protection Relays and Metering

Switchgear Meters



Switchgear Meters

Eaton's Power Xpert™ Power and Energy Meters, and Power Xpert Dashboard products allow switchgear owners and operators to interface with their equipment at varying levels of sophistication. To learn more about these devices, visit our website.

Protective Relays



Protective Relays

Eaton can provide a wide range of protective relays to meet your most complex protection and system needs.

Instrument Transformers

Instrument transformers are used to protect personnel and secondary devices from high voltage, and permit use of reasonable insulation levels for relays, meters and instruments. The secondaries of standard instrument transformers are rated at 5 A and/or 120 V, 60 Hz.

Voltage Transformers

Selection of the ratio for voltage transformers is seldom a question since the primary rating should be equal to or higher than the system line-to-line voltage. The number of potential transformers per set and their connection is determined by the type of system and the relaying and metering required.

When two VTs are used, they are typically connected L-L, and provide phase-to-phase voltages, (Vab, Vbc, Vca) for metering and relaying.

When three VTs are used, they are connected line-to-ground, and provide phase-to-phase (Vab, Vbc, Vca), as well as phase-to-ground (Va, Vb, Vc) voltages for metering and relaying.

If metering or relaying application requires phase-to-ground voltages, use three VTs, each connected L-G. If not, use of two VTs connected L-L is sufficient.

For ground detection, three VTs connected in Line-to-ground/broken-delta are used.

A single VT, when used, can be connected line-to-line (it will provide line-to-line output, for example Vab or Vbc or Vca), or line-to-ground (it will provide line-to-ground output, for example Va or Vb or Vc). Generally, a single VT is used to derive voltage signal for synchronizing or Overvoltage/Undervoltage function.

Current Transformers

The current transformer ratio is generally selected so that the maximum load current will read about 70% full scale on a standard 5 A coil ammeter. Therefore, the current transformer primary rating should be 140–150% of the maximum load current.

Maximum system fault current can sometimes influence the current transformer ratio selection because the connected secondary devices have published one-second ratings.

The zero-sequence current transformer is used for sensitive ground fault relaying or self-balancing primary current type machine differential protection. The zero-sequence current transformer is available with a nominal ratio of 50/5 or 100/5 and available opening size for power cables of 7.25 inches (184.2 mm). Special zero-sequence transformers with larger windows are also available.

The minimum number of current transformers for circuit relaying and instruments is three current transformers, one for each phase or two-phase connected current transformers and one zero-sequence current transformer. Separate sets of current transformers are required for differential relays.

The minimum pickup of a ground relay in the residual of three-phase connected current transformers is primarily determined by the current transformer ratio. The relay pickup can be reduced by adding one residual connected auxiliary current transformer. This connection is very desirable on main incoming and tie circuits of low resistance grounded circuits.

Standard accuracy current transformers are normally more than adequate for most standard applications of micro-processor-based protective relays and meters. See **Table 5.5-10** for CT accuracy information.

Table 5.5-8. Standard Voltage Transformer Ratio Information

Rating-Volts	2400	4200	4800	7200	8400	10800	12000	14400	15600	18000	21000	24000	27000	36000
Ratio	20-1	35-1	40-1	60-1	70-1	90-1	100-1	120-1	130-1	150-1	175-1	200-1	225-1	300-1

Table 5.5-9. Standard Voltage Transformer, 60 Hz Accuracy Information

Switchgear		Voltage Transformer—ANSI Accuracy											
kV Class	kV BIL	Maximum Number Per Set and Connection	Standard Ratios	Burdens at 120 Volts				Burdens at 69.3 Volts				Thermal Rating 55 °C Connection	Volt-Ampere
				W, X, Y	Z	M	ZZ	W, X	Y	M	Z		
27	125	2LL or 3LG	90, 100, 120, 130, 150, 175, 200, 225	0.3	0.3	0.3	1.2	0.3	0.3	0.3	1.2	LL LG LG ①	1000 550 1000

① For solidly grounded system only.

Note: LL = Line-to-line connection. LG = Line-to-ground connection.

Table 5.5-10. Current Transformers, 55 °C Ambient

CT Ratio (MR = Multi-Ratio)	Metering Accuracy Classification			Relaying Accuracy Classification		
	At 60 Hz Standard Burden B 0.1	At 60 Hz Standard Burden B 0.5	At 60 Hz Standard Burden B 1.8	Minimum Accuracy Required per IEEE C37.20.2	Standard Accuracy Supplied in VCP-W Switchgear	Optional High Accuracy Available in VCP-W Switchgear
50:5	1.2	—	—	C10	—	C10
75:5	1.2	2.4	—	C10	C10	C20
100:5	1.2	2.4	—	C10	C10	C20
150:5	0.6	2.4	—	C20	C20	C50
200:5	0.6	2.4	—	C20	C20	C50
250:5	0.6	2.4	—	②	C20	C50
300:5	0.6	2.4	2.4	C20	C20	C100
400:5	0.3	1.2	2.4	C50	C50	C100
500:5	0.3	0.3	2.4	②	C50	C100
600:5	0.3	0.3	2.4	C50	C100	C200
800:5	0.3	0.3	1.2	C50	C100	C200
1000:5	0.3	0.3	0.3	②	C100	C200
1200:5	0.3	0.3	0.3	C100	C200	C400
1500:5	0.3	0.3	0.3	C100	C200	C400
2000:5	0.3	0.3	0.3	C100	C200	C400
2500:5	0.3	0.3	0.3	②	C200	C400
3000:5	0.3	0.3	0.3	C100	C200	C400
4000:5	0.3	0.3	0.3	C100	C200	C400
600:5 MR	0.3	0.3	2.4	②	C100	C200
1200:5 MR	0.3	0.3	0.3	②	C200	C400
2000:5 MR	0.3	0.3	0.3	②	C200	C400
3000:5 MR	0.3	0.3	0.3	②	C200	C400
50:5 zero sequence	—	—	—	—	C10	—
100:5 zero sequence	—	—	—	—	C20	—

② Not listed in C37.20.2.

Note: Maximum number of CTs— Two sets of standard accuracy or one set of high accuracy CTs can be installed in the breaker compartment on each side of the circuit breaker.

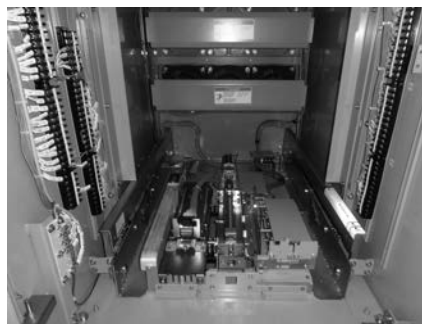
Dummy Element

Dummy element is a drawout element with primary disconnects similar to a drawout circuit breaker, but consists of solid copper conductors in place of vacuum interrupters, and is designed for manual racking. It is typically used as drawout disconnect link in the primary system for circuit isolation or bypass. The device is insulated to suit the voltage rating of the switchgear and will carry required levels of short-circuit current, but it is not rated for any current interruption.

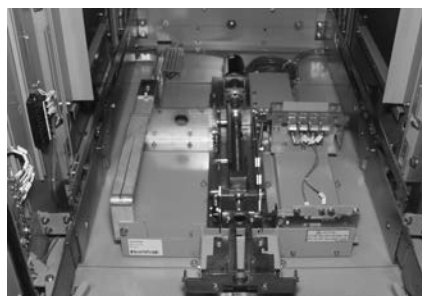
It must be key interlocked with all source devices such that it can only be inserted into or removed from its connected position only after the primary circuit in which it is to be applied is completely de-energized.

Before using a dummy element, it is recommended that each user develop detailed operating procedure consistent with safe operating practices. Only qualified personnel should be authorized to use the dummy element.

Integral Motorized Remote Racking Option (VC-W MR2)



Breaker Levering Pan Assembly with Test Position – VC-W MR2 Integral Racking Device



Type VC-W Arc-Resistant Switchgear Auxiliary Drawer with Type MR2 Integral Racking



Type VC-W Standard Switchgear Auxiliary Drawer with Type MR2 Integral Racking



MR2 Hand-Held Pendant

VC-W MR2 is an optional motorized racking device accessory installed inside a circuit breaker or auxiliary compartment. It is available for application in circuit breaker compartments of 5/15/27/38 kV Type VC-W arc and non-arc, and 5 kV VC-W ND metal-clad switchgear. It is also available for application in auxiliary compartments of 5/15 kV Type VC-W arc-resistant and standard switchgear. This optional accessory allows a user to safely move a circuit breaker between Connected, Test and Disconnected positions and auxiliary drawer (VT, CPT, primary fuse) between Connected and Disconnected positions within their respective compartments from a safe distance away from the switchgear. The MR2 controller also allows a user to electrically open and close the circuit breaker from a safe distance away from the switchgear. For switchgear designs/ratings not included above, contact Eaton for availability of MR2 accessory.

A microprocessor-based controller card, located below the drive motor, interfaces with an external hand-held pendant (standard), discrete external I/O (optional) or external Modbus communication (optional) and controls the breaker/auxiliary drawer movement via the drive motor. The system is also designed such that it allows manual racking of the breaker/auxiliary using the levering crank accessory if needed. The VC-W MR2 controller interface is shown in **Figure 5.5-4**. The crank safety switch disables the motor whenever a breaker/auxiliary is being manually racked in or out. The connect, test and disconnect limit switches provide breaker/auxiliary position inputs to the controller card. In addition to the standard permissive switch, two terminals are provided for connection of the customer's external interlocking/permissive contact(s). Note that a single-phase 120 Vac control supply is required for proper operation of the VC-W MR2 controller and the drive motor.

When VC-W MR2 integral racking is supplied, its controller card is wired to the CAT 6 jack installed in the associated breaker/auxiliary compartment door, and each switchgear lineup is shipped with one hand-held pendant with 30 feet of CAT 6 cable (lengths up to 100 ft available). The pendant interfaces with the MR2 controller card via the CAT 6 cable through a CAT 6 jack located on the breaker/auxiliary compartment door. It allows the operator to move away from the switchgear up to 30 feet. The pendant includes Enable pushbutton for additional security. It must be pressed in order to activate the pendant functions. By pressing Enable pushbutton and an appropriate function pushbutton together momentarily, the operator can rack the breaker between Connected, Test and Disconnected positions or open or close the breaker or rack the auxiliary drawer between Connected and Disconnected positions. Breaker or auxiliary drawer positions (Connect, Test, Disconnect) and breaker opened/closed status are indicated by appropriate LED lights on the pendant. A blinking light indicates that the breaker/auxiliary is in motion through the selected position.

A solid (non-blinking) light indicates that the breaker/auxiliary has reached and stopped in the selected position. In case normal operation fails, the appropriate error code is displayed in a separate two-character LED display window on the pendant. A list of various error codes and their descriptions along with suggested corrective actions are printed on the back side of the pendant. Examples of error states: motor overcurrent, motor overtemperature, motor timed out, breaker position unknown, open permissive, communication error and no breaker/auxiliary.

In addition to pendant, three optional I/O interfaces can be supplied as follows:

1. I/O interface to allow racking of breaker (connect, test, disconnect) or auxiliary drawer (connect, disconnect) by external hardwired dry contacts and 24 Vdc output for corresponding remote position indicating LEDs.
2. I/O board that provided dry contacts for remote indication of breaker (connect, intermediate, test, disconnect)/auxiliary drawer (connect, test) position within its compartment.
3. I/O interface to allow breaker open/close functions via external hardwired dry contacts and 24 Vdc output for corresponding remote open/close status LEDs.

The remote LED lights are not included with MR2. If the customer needs to operate the MR2 with the hand-held pendant, the pendant becomes the master and will override the customer's remote control signals.

The VC-W MR2 controller is also equipped with terminal blocks to allow the customer to interface with the controller via their SCADA system using a Modbus interface. Please note that only one of the two options, discrete I/O interface or Modbus interface, can be used, but not both. **Figure 5.5-5** shows an illustration of a typical Modbus control example. Additional components shown outside the MR2 controller in **Figure 5.5-5** are not included with the MR2. System-level controls can be optionally supplied by Eaton's Engineering Services & Systems. If the customer needs to operate the MR2 with the hand-held pendant, the pendant becomes the master and will override the Modbus interface. Error codes are displayed on Modbus devices when controlling the MR2 with Modbus and on the pendant when controlling with the pendant.

Technical Data

Control Supply Ratings

- Nominal control voltage—120 Vac, 50 or 60 Hz, single-phase
- Control voltage range—100 to 140 Vac, 50 or 60 Hz
- Time to travel from connect to disconnect, or disconnect to connect—50 seconds maximum
- Current draw during the travel—15 A maximum for about 3 seconds and 3.6 A for about 24 seconds
- Optional dry output contacts when included for position indications are rated for 125 Vac, 2 A
- External permissive contacts, when used, must be rated for 24 Vdc, 50 mA

Requirements for External Contacts and LEDs when Interfacing with MR2

- External contacts should be rated for minimum open circuit voltage of 24 Vdc, and be able to close and carry 5 mA at 24 Vdc
- When remote LEDs are used, use 24 Vdc rated LEDs, current up to 20 mA
- Optional dry output contacts when included for position indications are rated for 125 Vac, 2 A
- External permissive contacts, when used, must be rated for 24 Vdc, 50 mA

It is the customer's responsibility to provide single-phase 120 V, 50 or 60 Hz nominal supply for the MR2 controller. It can be derived from within the switchgear if an appropriate control power transformer is available within the switchgear.

Type VC-W MR2 motorized racking accessory has been endurance tested and guaranteed for 500 operations as required by IEEE C37.20.2.

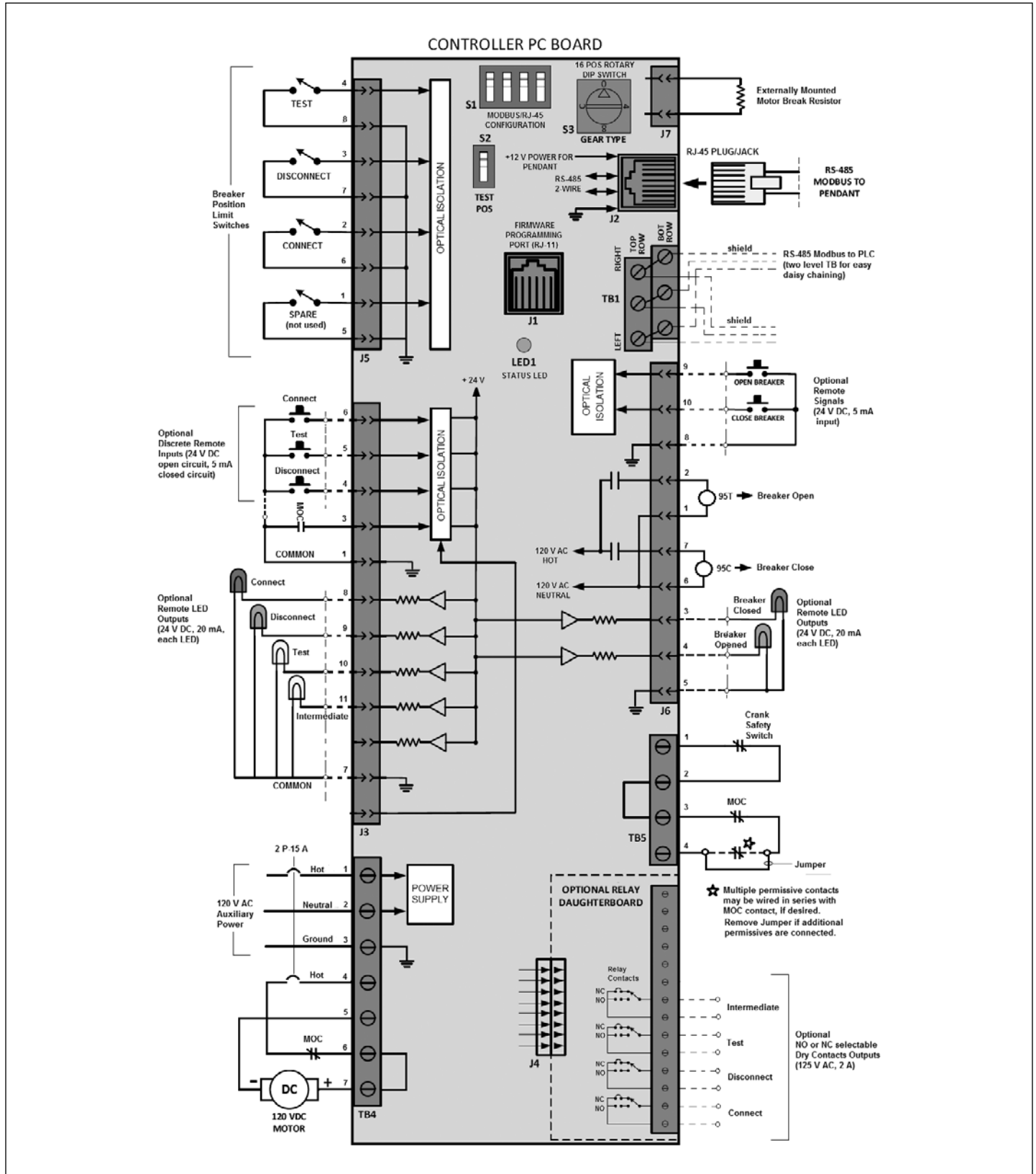


Figure 5.5-4. VC-W MR2 Controller Interface for a VCB with Distinct Test Position and Open/Close Functions

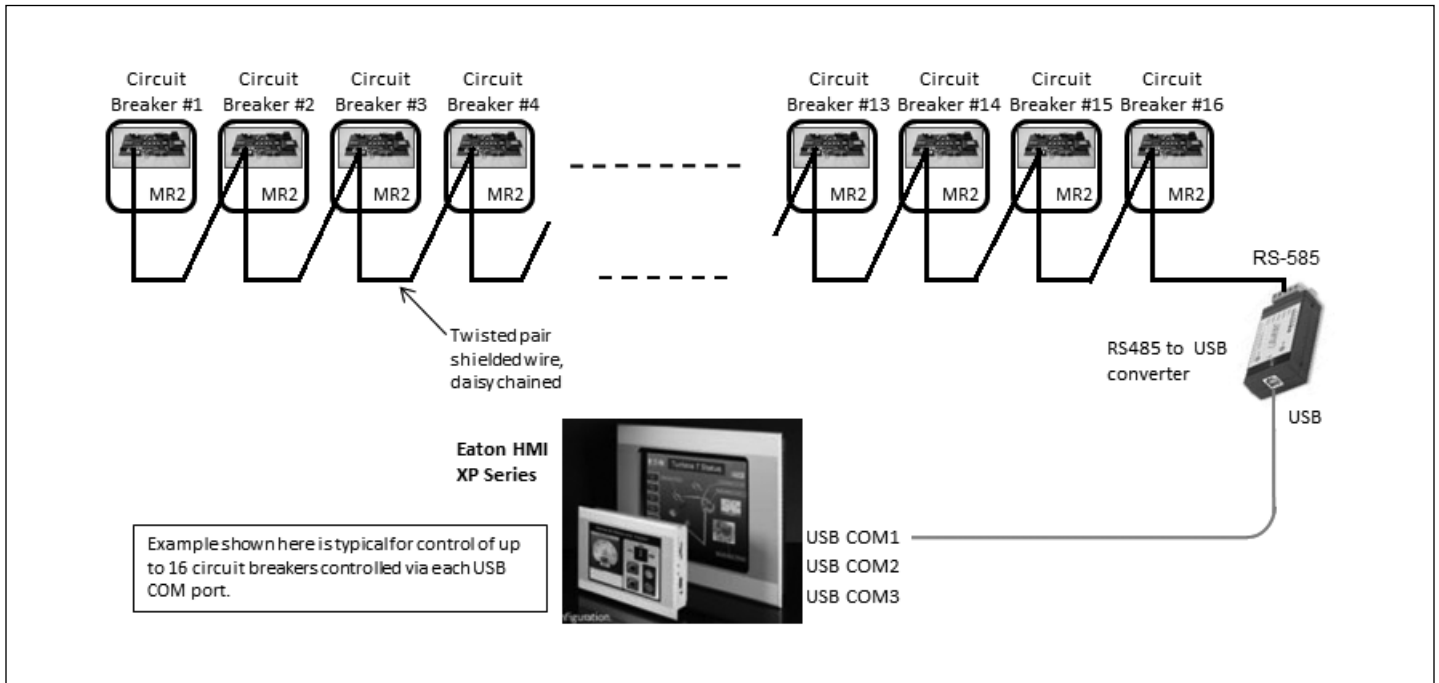


Figure 5.5-5. VC-W MR2 Typical Modbus Control Example

Accessories

Ground and Test Device

The ground and test device is a drawout element that may be inserted into a metal-clad switchgear housing in place of a circuit breaker to provide access to the primary circuits to permit the temporary connection of grounds or testing equipment to the high-voltage circuits. High potential testing of cable or phase checking of circuits are typical tests which may be performed. The devices are insulated to suit the voltage rating of the switchgear and will carry required level of short-circuit current.

Before using ground and test devices, it is recommended that each user develop detailed operating procedures consistent with safe operating practices. Only qualified personnel should be authorized to use ground and test devices.

Manual and electrical ground and test devices are available. These devices include six studs for connection to primary circuits. On the manual device, selection and grounding is accomplished by cable or bus bars connection. On electrical-type devices, grounding is accomplished by an electrically operated grounding switch.

Standard Accessories

- One test jumper
- One levering crank
- One maintenance tool
- One lifting yoke (5–27 kV)
- One sets of rails (5–27 kV)
- One turning handle (5th wheel, 38 kV)

Optional Accessories

- Transport dolly (5–27 kV), (5–15 kV arc-resistant)
- Portable lifter (5–27 kV)
- Test cabinet
- Electrical levering device (5–38 kV)
- Ramp for lower breaker (5–27 kV), (5–15 kV arc-resistant)
- Manual or electrical ground and test device
- Hi-pot tester
- Integral motorized remote racking (VC-W MR2) for circuit breaker
- Integral motorized remote racking (VC-W MR2) for auxiliary drawer

System Options

Partial Discharge Sensing and Monitoring for Switchgear



InsulGard Relay



RFCT Sensor

Partial Discharge Equipment



InsulGard Relay (PD Monitoring)

Partial Discharge in Switchgear

Partial discharge is a common name for various forms of electrical discharges such as corona, surface tracking, and discharges internal to the insulation. It partially bridges the insulation between the conductors. These discharges are essentially small arcs occurring in or on the surface of the insulation system when voltage stress exceeds a critical value. With time, airborne particles, contaminants and humidity lead to conditions that result in partial discharges. Partial discharges start at a low level and increase as more insulation becomes deteriorated. Examples of partial discharge in switchgear are surface tracking across bus insulation, or discharges in the air gap between the bus and a support, such as where a bus passes through an insulating window between the sections of the switchgear. If partial discharge process is not detected and corrected, it can develop into a full-scale insulation failure followed by an electrical fault. Most switchgear flashover and bus failures are a result of insulation degradation caused by various forms of partial discharges.

Sensing and Monitoring

Eaton's Type VCP-W metal-clad switchgear (2.4–38 kV) is corona-free by design. Corona emissions within the standard VacClad switchgear assemblies have been eliminated or reduced to very low levels by special fabrication and assembly techniques, such as rounding and buffing of all sharp copper edges at the joints, employing star washers for bolting metal barriers, and using specially crafted standoff insulators for primary bus supports. By making switchgear assemblies corona-free, Eaton has made its standard switchgear more reliable. However, as indicated above, with time, airborne particles, contaminants and humidity lead to conditions that cause partial discharges to develop in switchgear operating at voltages 4000 V and above. Type VC-W switchgear can be equipped with factory-installed partial discharge sensors and partial discharge sensing relay for continuous monitoring of the partial discharges under normal operation. Timely detection of insulation degradation through increasing partial discharges can identify potential problems so that corrective actions can be planned and implemented long before permanent deterioration develops. Partial discharge detection can be the foundation of an effective predictive maintenance program. Trending of partial discharge data over time allows prediction of failures, which can be corrected before catastrophic failure occurs.

The PD sensing and monitoring system is optional. It consists of Eaton's InsulGard™ Relay and PD sensors specifically developed for application in the switchgear to work with the relay.

Partial discharges within the switchgear compartment are detected by installation of a small donut type radio frequency current transformer (RFCT) sensor over floating stress shields of the specially designed bus or line side primary bushings. Partial discharges in customer's power cables (external discharges) are detected by installation of the RFCT around ground shields of the incoming or outgoing power cables termination.

In 27/38 kV switchgear (refer to **Figure 5.5-7**), when specified, a set of coupling capacitor sensors is installed in the rear compartment and connected to the primary circuit at every two vertical sections for measurement of discharges internal to the switchgear compartment. The sensor's output is wired to terminal blocks in control compartment for easy access for periodic field measurements. The sensor can also be connected directly to optional InsulGard relay for continuous monitoring of partial discharges. An additional RFCT sensor for each incoming and outgoing power cable circuits can be provided for measurement of external discharges.

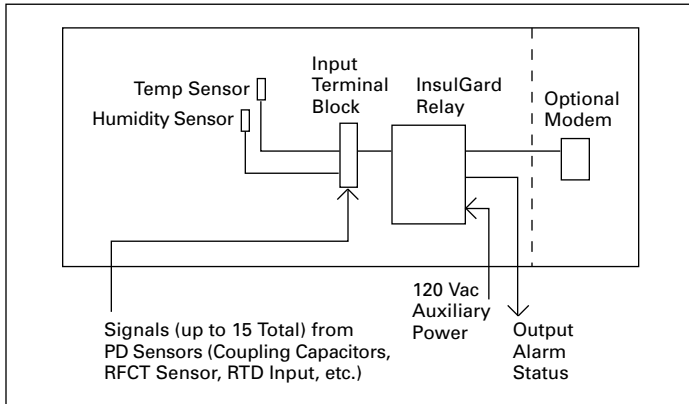


Figure 5.5-6. InsulGard Relay System

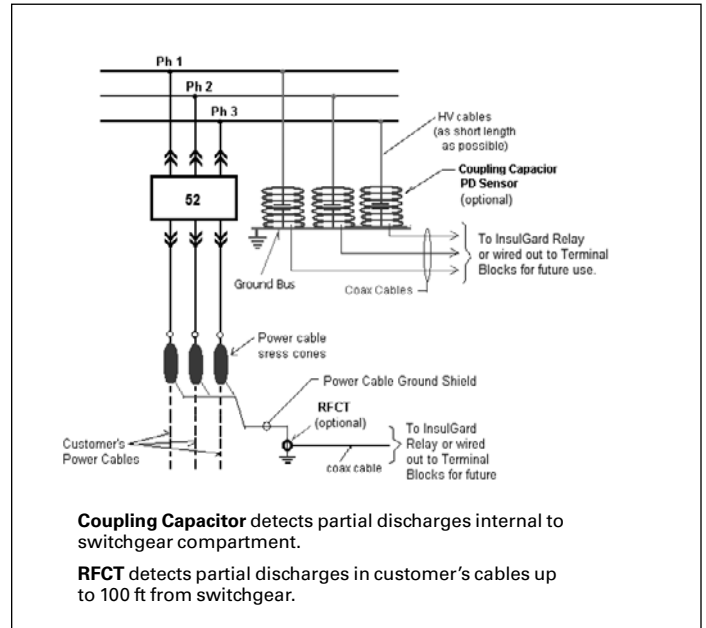


Figure 5.5-7. Typical Partial Discharge Sensor Connections (27/38 kV Switchgear)

Typical Application Layouts

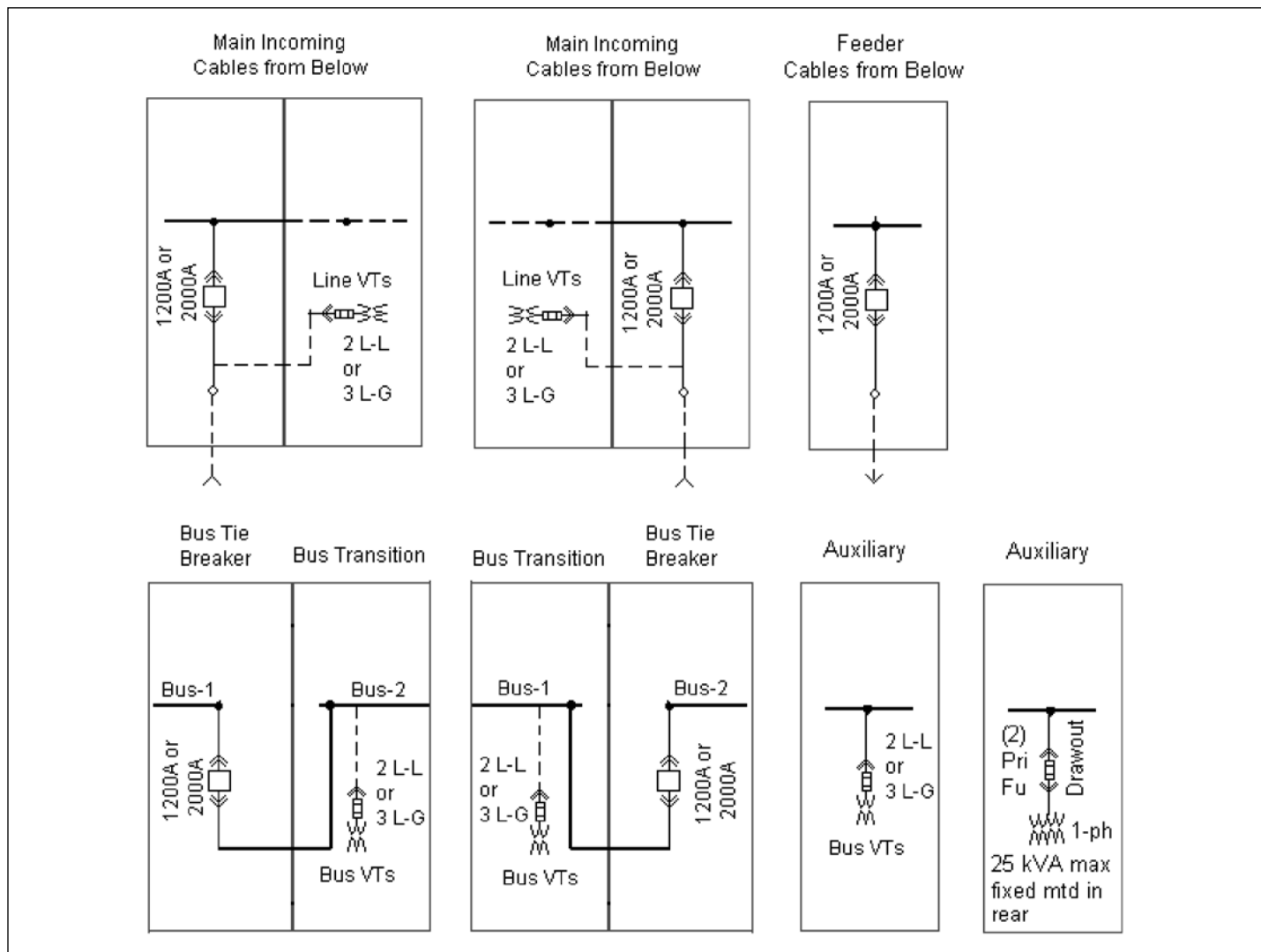


Figure 5.5-8. Typical Arc-Resistant Switchgear Application Layouts—27 kV

Notes:

1. Maximum number of CTs: Two sets of standard or one set of high accuracy CTs can be installed on each side of the circuit breaker.
2. Bottom entry is standard for all power cables, maximum four per phase.
3. Refer to **Figure 5.5-9** to **Figure 5.5-11** for dimensions.
4. 27 kV arc-resistant switchgear can be supplied in one-high design configuration only.

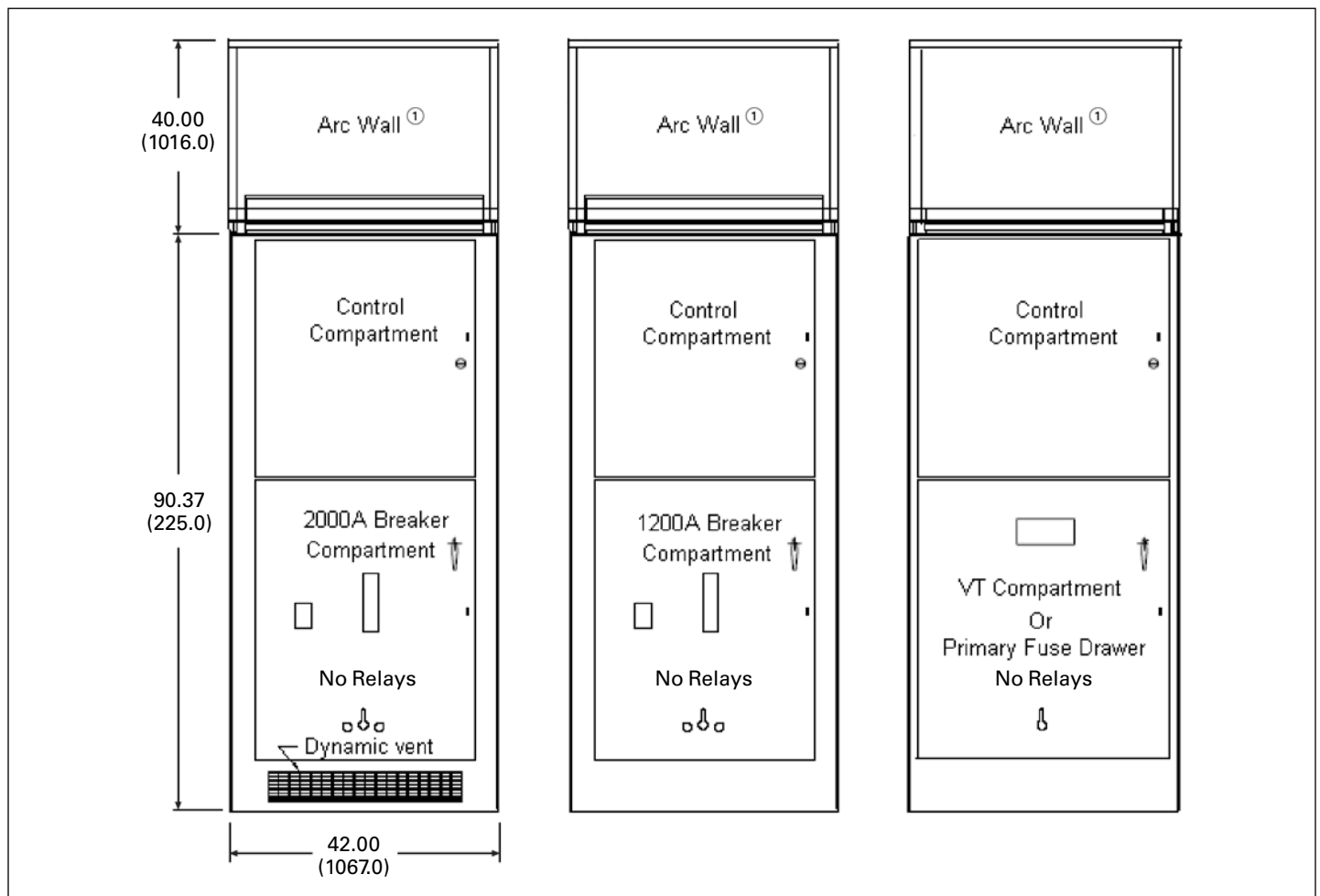


Figure 5.5-9. Available Arc-Resistant Switchgear Configurations (Front Views)—27 kV

① Please note that an additional 48.00-inch (1219.2 mm) clearance is required above the arc wall for arc exhaust.

Typical Sectional Side Views—Dimensions in Inches (mm)

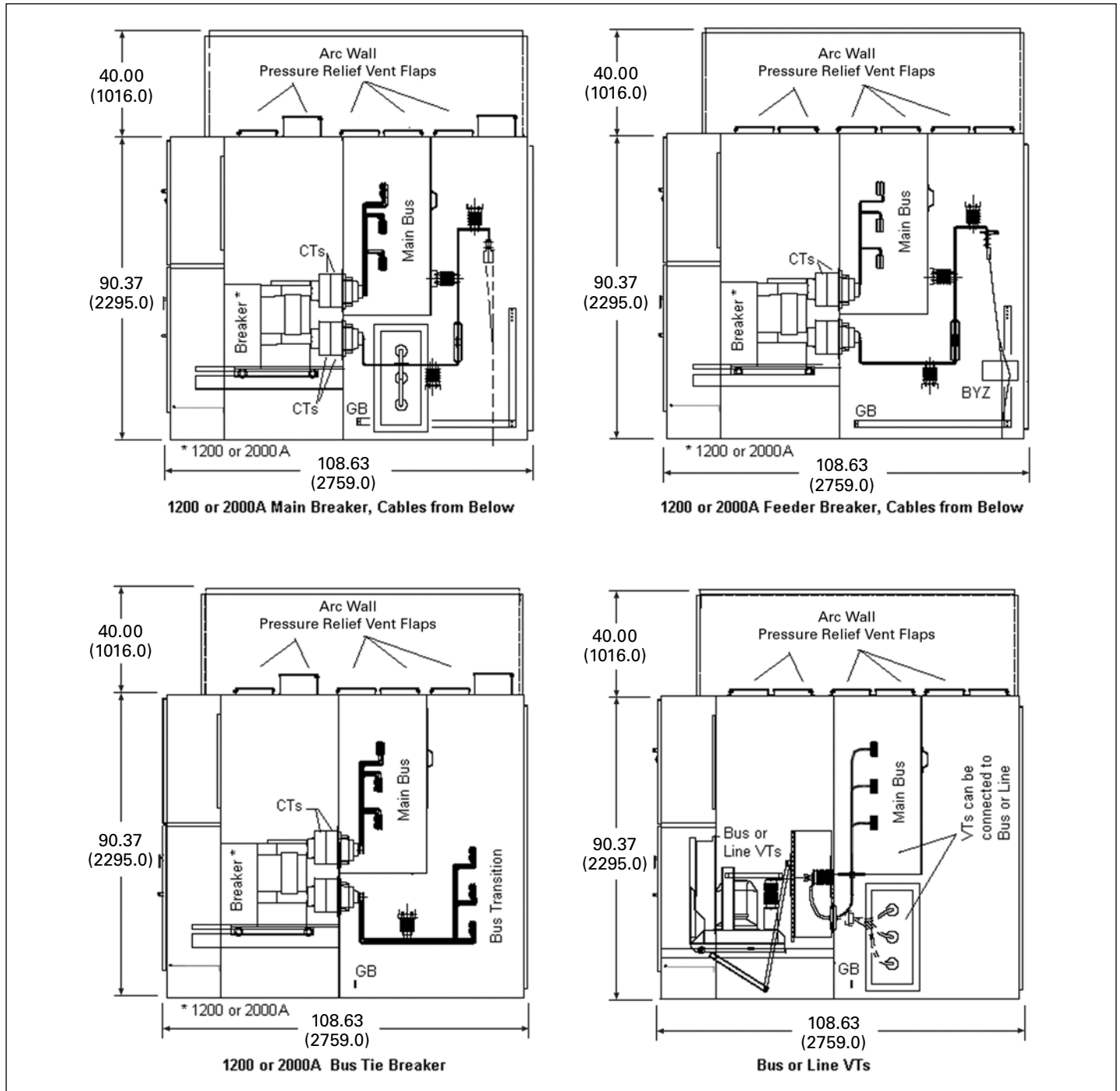


Figure 5.5-10. Typical Arc-Resistant Switchgear Sectional (Side Views)—27 kV

Typical Floor Plan—Dimensions in Inches (mm)

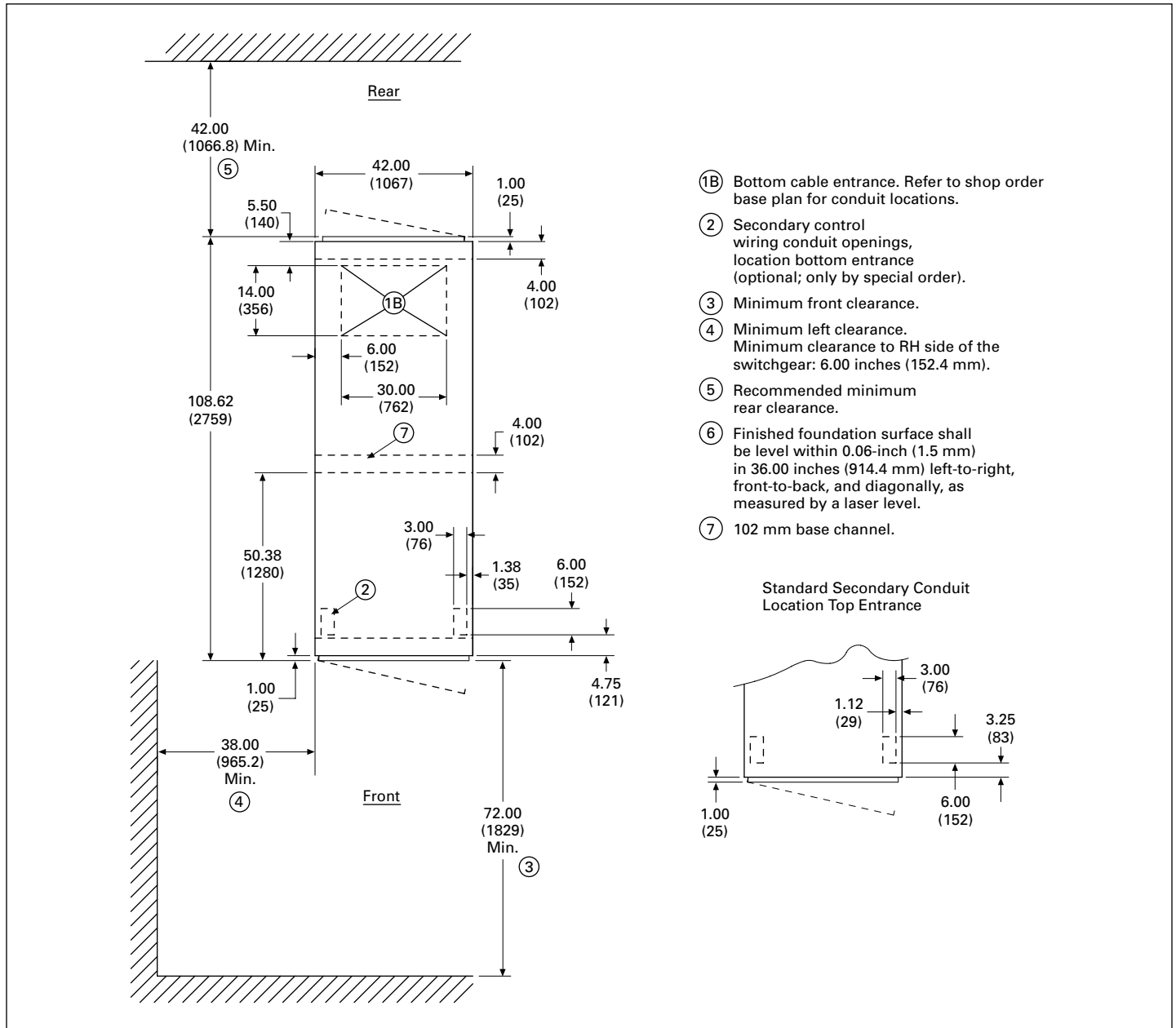


Figure 5.5-11. Typical Arc-Resistant Switchgear Floor Plan—27 kV

Arc Exhaust Wall—for 27 and 38 kV Switchgear

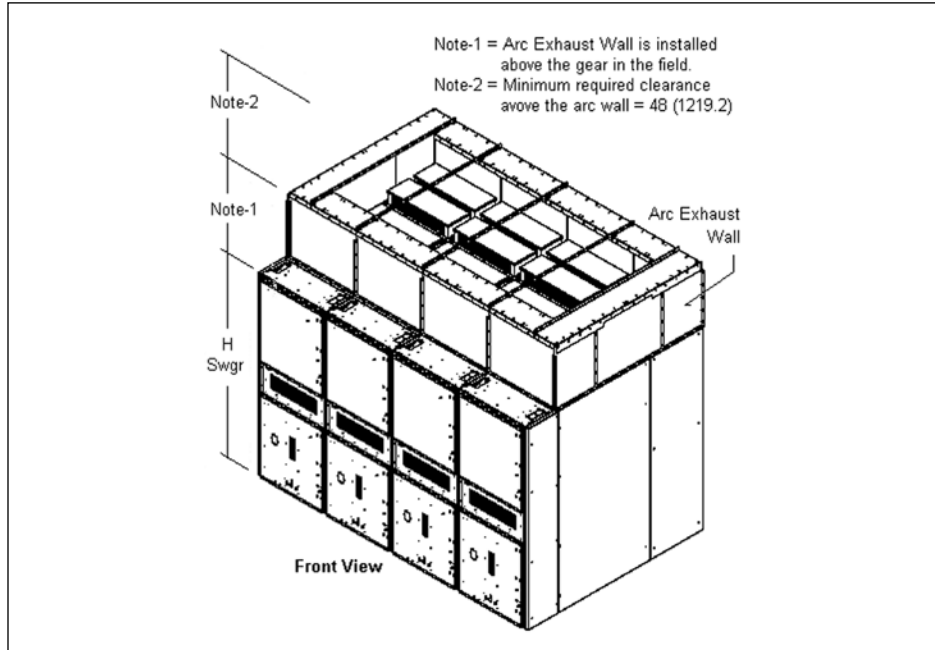


Figure 5.5-12. Arc Exhaust Wall Above the Switchgear

Arc Exhaust wall **Figure 5.5-12** is supplied as standard for all 27/38 kV arc-resistant switchgear. The arc exhaust wall must be field installed above the switchgear. Note minimum 48.00-inch (1219.2 mm) ceiling clearance is required above the arc exhaust wall for proper venting of the arc exhaust. All 5/15 kV arc-resistant switchgear is provided with arc exhaust chamber (plenum). It is also installed in the field. When using arc exhaust chamber, minimum ceiling clearance required above the arc exhaust chamber (plenum) is equal to that needed for field installation of the chamber. Eaton recommends minimum 18.00-inch (457.2 mm).

Note: APPLICABLE TO ALL ARC-RESISTANT SWITCHGEAR:

For switchgear with enclosure arc ratings of up to 41 kA rms symmetrical, minimum two vertical sections and one arc duct exit is required.

For switchgear with enclosure arc rating of 50 kA rms symmetrical or higher, minimum three vertical sections and two arc duct exits are required.

Arc Exhaust Chamber (Plenum) with Arc Duct Exit—for 5 and 15 kV Switchgear

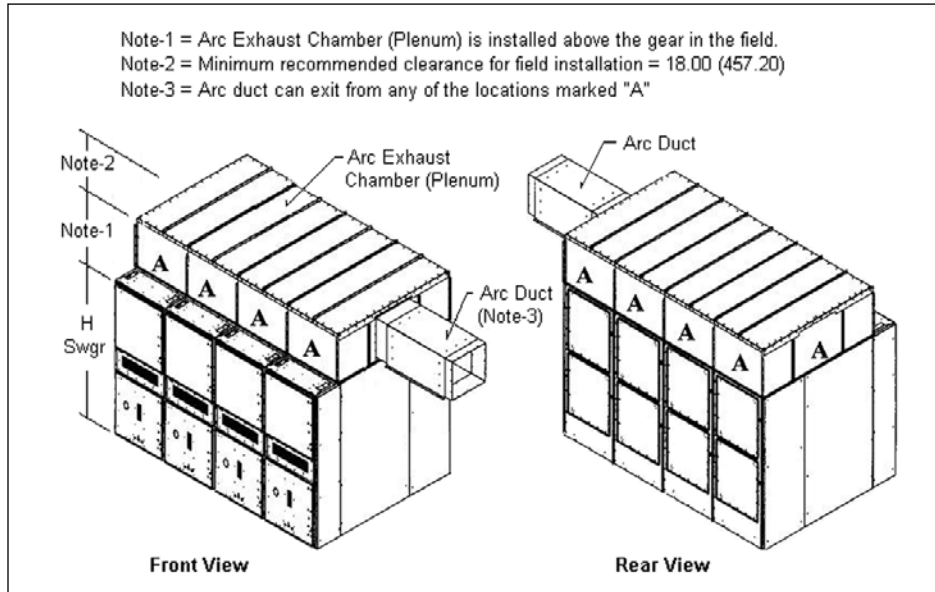


Figure 5.5-13. Arc Exhaust Chamber (Plenum) with Arc Duct Exit Above the Switchgear

Weights

Typical Weights in Lb (kg)

Table 5.5-11. Assemblies (Less Breakers)

Type of Vertical Section	Main Bus Rating Amperes	Indoor Structure
Control/breaker	1200	2700 (1226)
	2000	2800 (1271)
Control/auxiliary	1200	2400 (1090)
	2000	2500 (1135)

Control Power

Table 5.5-12. VCP-W Breaker Stored Energy Mechanism Control Power Requirements

Rated Control Voltage	Spring Charging Motor			Close or Trip Amperes	UV Trip mA Maximum	Voltage Range		Indicating Light Amperes
	Inrush Amperes	Run Amperes	Average Run Time, Sec.			Close	Trip	
48Vdc	36.0	9	6	16	200	38–56	28–56	0.02
125Vdc	16.0	4	6	7	80	100–140	70–140	0.02
250Vdc	9.2	2	6	4	40	200–280	140–280	0.02
120Vac	16.0	4	6	6	—	104–127	104–127	0.02
240Vac	9.2	2	6	3	—	208–254	208–254	0.02

Table 5.5-13. Control Power Transformers—Single-Phase, 60 Hz ②

Rated Primary Voltage, Volt	Rated Secondary Voltage, Volt	kVA	kV Class
2400	240–120	5, 10, 15	5
4160	240–120	5, 10, 15	5
4800	240–120	5, 10, 15	5
7200	240–120	5, 10, 15	15
8400	240–120	5, 10, 15	15
12470	240–120	5, 10, 15	15
13200	240–120	5, 10, 15	15
13800	240–120	5, 10, 15	15
23000	240–120	5, 10, 15	27
34500	240–120	15, 25	38 ③

② Line-to-line connection only available. Refer to Eaton for other voltages and kVA ratings.

③ 150 kV BIL.

Heat Loss

Table 5.5-14. Heat Loss in Watts at Full Rating, at 60 Hz

Type of Switchgear Assembly	Breaker Rating	1200 A	2000 A	2500 A	3000 A	4000 A Fan Cooled
VCP-W	5, 15 and 27 kV	600W	1400W	—	2100W	3700W
VCP-W	38 kV	850W	1700W	2300W	3800W	—
Other Components						
Each CT, standard accuracy	50W					
Each CT, high accuracy	100W					
Each VT	60W					
CPT single-phase, 25 kVA	450W					
CPT single-phase, 45 kVA	892W					
Space heater—each	250W					

Typical Schematics

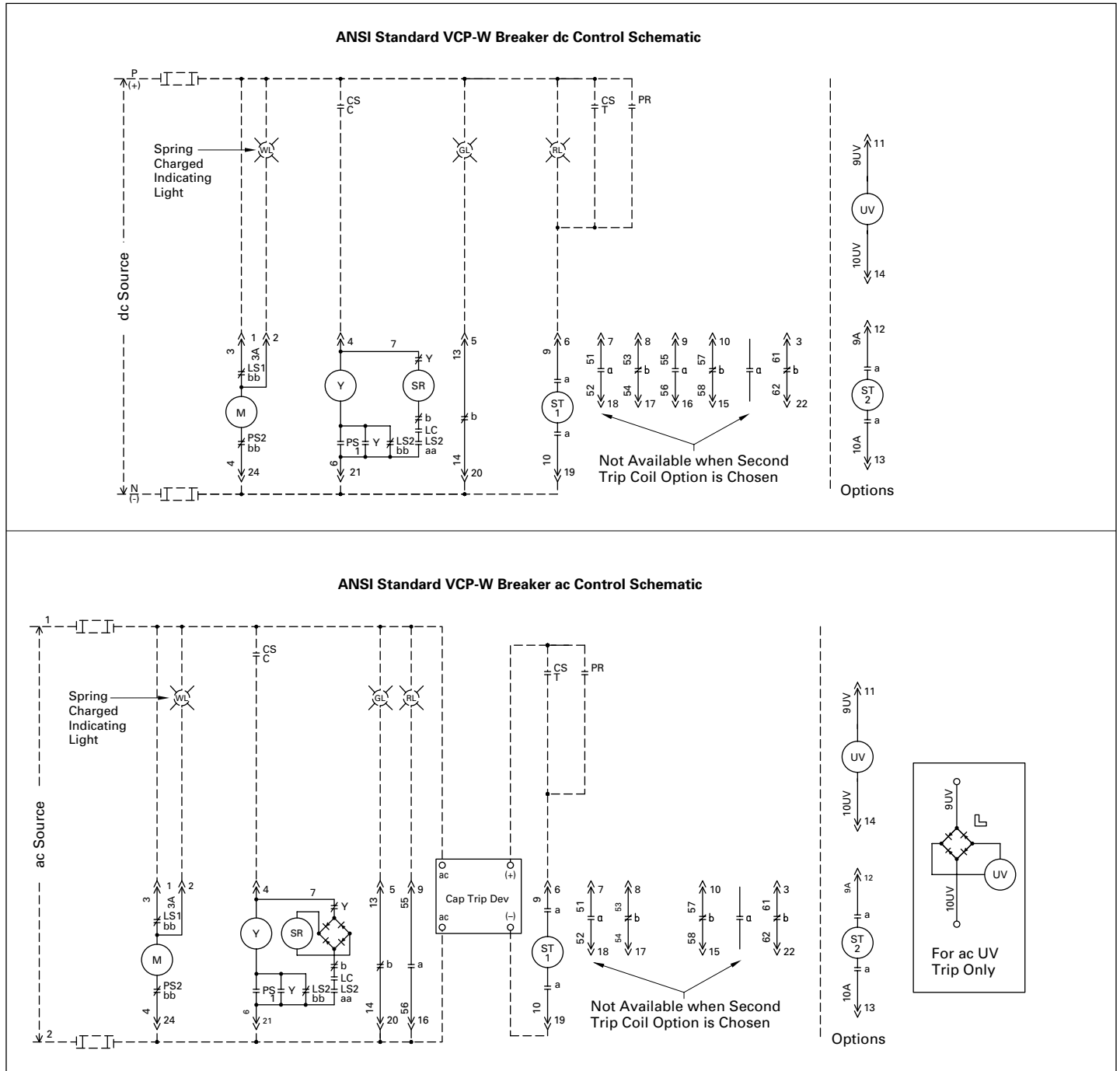


Figure 5.5-14. Typical 5/15/27 kV VCP-W "dc" and "ac" Control Schematics

Note: **CS** = Breaker Control Switch–Close
C = Breaker Control Switch–Trip
Y = Anti Pump Relay
SR = Spring Release Coil (Coil)
M = Spring Charge Motor
ST = Shunt Trip
PR = Protective Relay
Λ = Secondary Disconnect

Note: **LS1** = Closed until springs are fully charged.
LS2 = Open until springs are fully charged.
aa = Closed until springs are fully charged.
bb = Open until mechanism is reset.
PS1 = Open in all except between "Test" and "Connected" positions.
PS2 = Closed in all except between "Test" and "Connected" positions.

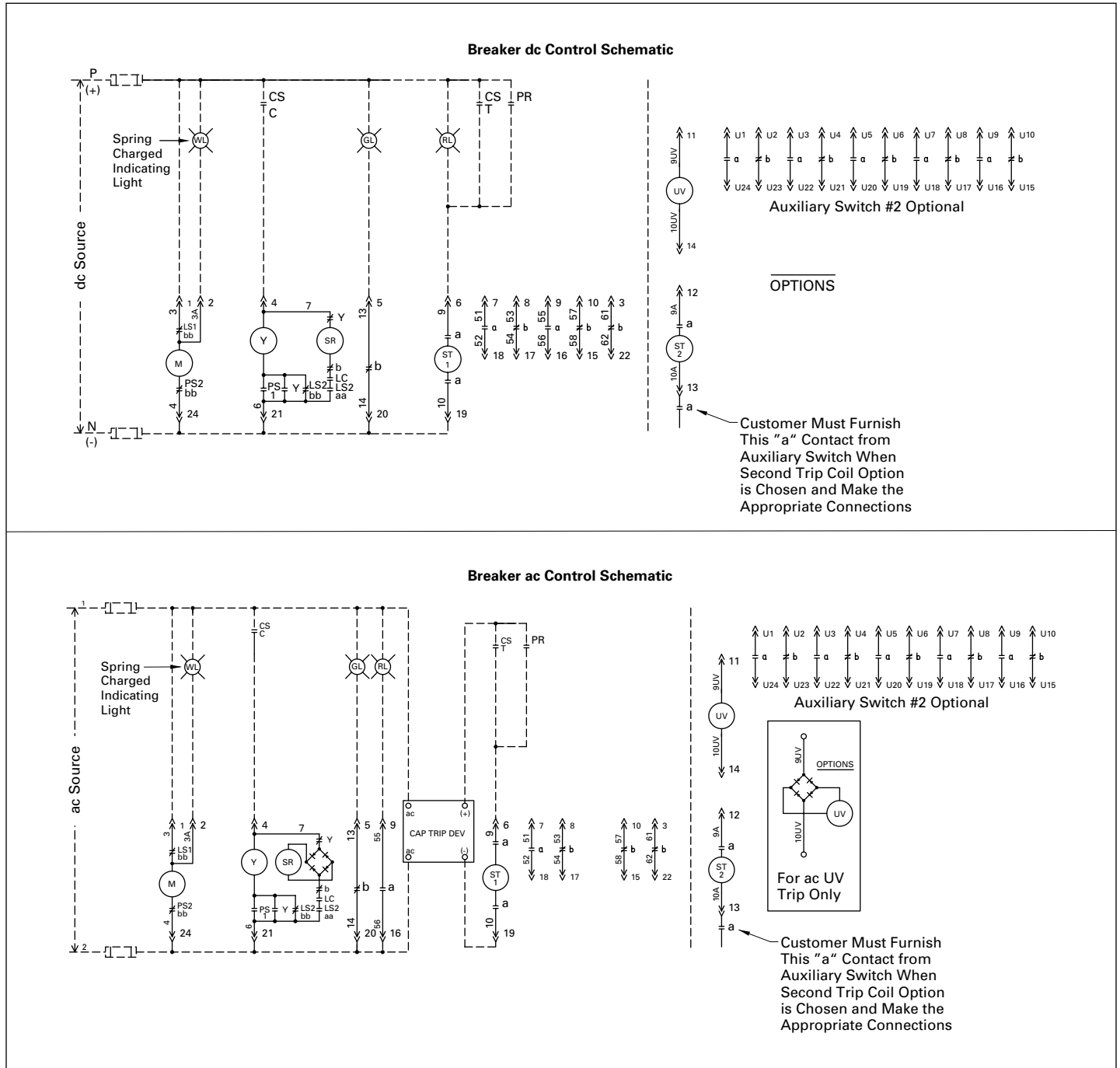


Figure 5.5-15. Typical 38 kV VCP-W “dc” and “ac” Control Schematics

Note: **CS** = Breaker Control Switch–Close
C = Breaker Control Switch–Close
CS = Breaker Control Switch–Trip
T = Breaker Control Switch–Trip
Y = Anti Pump Relay
SR = Spring Release Coil (Coil)
M = Spring Charge Motor
ST = Shunt Trip
PR = Protective Relay
Λ = Secondary Disconnect

Note: **LS1** = Closed until springs are fully charged.
bb = Closed until springs are fully charged.
LS2 = Open until springs are fully charged.
aa = Open until springs are fully charged.
LS2 = Closed until springs are fully charged.
bb = Closed until springs are fully charged.
LC = Open until mechanism is reset.
PS1 = Open in all except between “Test” and “Connected” positions.
PS2 = Closed in all except between “Test” and “Connected” positions.

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