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Metal-enclosed switchgear, MEB utilizing medium-voltage vacuum breakers

Contents

Powering Business Worldwide

MEB Metal-Enclosed Drawout Breaker

General Description

Eaton's MEB (metal-enclosed breaker) switchgear assemblies consist of a single-high drawout vacuum circuit breaker (Type VCP-W) in a metal-enclosed cabinet. This equipment has been designed primarily where metal-clad switchgear is not required and a switch or switch and fuse combination are not suitable. As primary protection for single-ended substations, it can eliminate the need for a secondary main circuit breaker. It can also be applied as the primary main device and integrated with fused or unfused feeder switches in an Eaton Type MVS load interrupter switchgear assembly. Two and three breaker automatic transfer schemes are also available.

MEB switchgear assemblies utilize an overcurrent protective device that provides increased system protection and increased coordination with upstream and downstream devices where these benefits cannot be achieved with a switch and fuse combination. Vacuum circuit breakers provide the following features:

- High interrupting capacity suitable for use with ground fault equipment and differential relay schemes
- High duty cycle
- Adjustable overcurrent protection
- Expanded protective relay functions, such as those provided in the EDR-5000
- Three-phase tripping; no single phasing on tripping
- Maintainable
- Long equipment life
- Special applications, such as capacitor switching, are possible with breakers

Type MEB switchgear provides a minimal footprint using vacuum breaker technology. Protective devices and meters are conveniently mounted on the switchgear structure door.

Type VCP-W vacuum circuit breakers have been designed with a V-Flex™ current transfer system that provides a unique non-sliding current transfer arrangement, no maintenance, excellent electrical and thermal transfer, and long vacuum interrupter life.

Both indoor and outdoor non-walk-in enclosures are available. Uses are single or multiple circuits, transformer primaries and mains for MVS applications. Configurations with an automatic transfer control system can be easily accommodated. Drawout vacuum breakers are ideal for high duty cycle, as well as applications requiring rapid return to service after a load fault.

Type MEB switchgear is one product of choice for ground fault interruption when air interrupters alone would be potentially hazardous if called on to operate above their assigned interrupting ratings. Capacitor switching is easily handled by MEB, avoiding the restrike hazard presented by air switches.

Standardized designs cover most common applications, while custom designs are also available for unusual requirements.

Type MEB vacuum switchgear meets or exceeds the following industry standards: ANSI/IEEE® C37.20.3, ANSI/IEEE C37.20.4, ANSI C37.22, ANSI C37.57, ANSI C37.58, NEMA® SG5, NEMA SG6, CSA® 22.2 No. 31-04, EEMAC G8-3.3. It is also CSA listable for Canada and U.S. markets.

MEB circuit breaker sections are easily mixed with MVS fused switch sections in lineups. No bus transitions are required between them except where bus runs from top to bottom locations, such as between main and feeder sections.

MEB with Complete Access to Control Switches, Overcurrent Relays and Meters, as well as Breakers

Construction

Current and voltage transformers associated with protection devices such as the EDR-3000 or EDR-5000 electronic overcurrent relays are applied using the same ratings as drawout metal-clad switchgear. Metering and protective relay devices are mounted on the single front hinged door. The front door may be opened at any time to provide access to low-voltage components and to the front of the circuit breaker, without being exposed to high voltage.

The Power Xpert® and IQ family of electronic meters is normally used when metering functions are required.

The circuit breaker is racked into position, and can easily be withdrawn and removed from the enclosure with grounded steel shutters, preventing accidental contact with primary voltage connections. Routine maintenance can be performed on the circuit breaker mechanism in the enclosure.

Standard MEB insulators are NEMA rated glass polyester or optional epoxy. Control power is required. The AC control power can be supplied integrally if specified. DC control power, if required, must be furnished by others.

If AC control power is used, a capacitor trip device is provided as standard.

Once the circuit breaker is closed and the closing spring is recharged, the breaker can open, close and open without spring recharge.

Standard MEB Switchgear Assembly Ratings

Table 7.1-1. MEB Assembly Main Bus Ratings ①

Rated Maximum Volts kV	Rated BIL kV	Rated Main Bus Current Amperes	Rated Momentary Current kA rms Asymmetrical	Rated Short-TIme (2 Seconds) Current kA Symmetrical
4.76	60	600	40	25
4.76	60	600	61	38
4.76	60	600	80	50
4.76	60	1200	40	25
4.76	60	1200	61	38
4.76	60	1200	80	50
4.76	60	1200	101	63
4.76	60	2000	40	25
4.76	60	2000	61	38
15	95	600	40	25
15	95	600	61	38
15	95	600	80	50
15	95	1200	40	25
15	95	1200	61	38
15	95	1200	80	50
15	95	1200	101	63

① The switchgear assembly is designed for use with Type VCP-W, VCP-WC and VCP-WG circuit breakers. However, please note that certain VCP-WC circuit breakers may have higher capabilities than required by ANSI standards. In such cases, switchgear assembly ratings as given in this table will apply.

Circuit Breakers

Table 7.1-2. Available Type VCP-W, VCP-WC and VCP-WG Vacuum Circuit Breakers Rated per ANSI Standards

Circuit Breaker Type ①②③④	Rated Maximum Voltage	Rated Voltage Range Factor	Rated Continuous Current	Rated Short-Circuit Current at Rated Maximum Voltage	Maximum Symmetrical Interrupting and 3-Second Short-Time Current Carrying Capability	Closing and Latching Capability (Momentary)	
	V	K		I	K * I	⑤	⑥
	kV rms		Amperes	kA rms Symmetrical	kA rms Symmetrical	kA Peak	kA rms Asym
50 VCP-W 250	4.76	1.24	1200	29	36	97	58
50 VCP-W 350	4.76	1.19	1200	41	49	132	78
50 VCP-W 500	4.76	1.0	1200	63	63	170	101
75 VCP-W 500	8.25	1.25	1200	33	41	111	66
150 VCP-W 500	15	1.3	1200	18	23	62	37
150 VCP-W 750	15	1.3	1200	28	36	97	58
150 VCP-W 1000	15	1.3	1200	37	48	130	77
150 VCP-W 1500	15	1.0	1200	63	63	170	101
50 VCP-W 25	4.76	1.0	1200	25	25	65	40
50 VCP-W 40	4.76	1.0	1200	40	40	104	64
50 VCP-W 50	4.76	1.0	1200	50	50	130	80
50 VCP-W 63	4.76	1.0	1200	63	63	164	100.8
75 VCP-W 50	8.25	1.0	1200	50	50	130	80
150 VCP-W 25	15	1.0	1200	25	25	65	40
150 VCP-W 40	15	1.0	1200	40	40	104	64
150 VCP-W 50	15	1.0	1200	50	50	130	80
150 VCP-W 63	15	1.0	1200	63	63	164	100.8
50 VCP-WG 50	4.76	1.0	1200	50	50	137	82
50 VCP-WG 63	4.76	1.0	1200	63	63	173	103
150 VCP-WG 50	15	1.0	1200	50	50	137	82
150 VCP-WG 63	15	1.0	1200	63	63	173	103

① For detailed ratings of Type VCP-W circuit breakers, refer to **Table 7.1-4**.
② For detailed ratings of Type VCP-WC circuit breakers, refer to **Table 7.1-5**.
③ For detailed ratings of Type VCP-WG circuit breakers, refer to **Table 7.1-6** and **Table 7.1-7**.
④ Please note certain Eaton breakers may have higher capabilities than required by ANSI standards. When these breakers are applied in an MEB switchgear assembly, the assembly ratings as given in **Table 7.1-2** will apply.
⑤ Close and latch capability shown is 2.7*K*I for circuit breakers rated on the basis of K>1, and 2.6*K*I for those rated on the basis of K =1.
⑥ Close and latch capability shown in asymmetrical rms is 1.6*K*I for all circuit breakers. It exceeds the required capability of 1.55*K*I for breakers rated on the basis of K =1.

Breaker Control Ratings

Table 7.1-3. VCP-W Breaker Stored Energy Mechanism Control Power Requirements

Rated Control Voltage	Spring Charge Motor			Close or Trip Amperes	Voltage Range	
	Inrush Amperes	Run Amperes	Time Seconds		Close	Trip
48 Vdc	36.0	9.0	6	16	38–56	28–56
125 Vdc	16.0	4.0	6	7	100–140	70–140
250 Vdc	9.2	2.0	6	4	200–280	140–180
120 Vac	16.0	4.0	6	6	104–127	104–127
240 Vac	9.2	2.0	6	3	208–254	208–254

Discussion of Changes in the Rated Voltage Range Factor, K, or "K-factor" in Circuit Breaker Rating Structure

In 1997 and 2000 editions of ANSI C37.06, under Table 1, preferred values for the rated voltage range factor, "K" were set to 1.0 for all indoor circuit breaker ratings. This was done because interrupting capabilities of today's vacuum circuit breakers are better represented by K = 1.0. Unlike old air-magnetic and oil circuit breakers, today's vacuum breakers generally do not require a reduction in interrupting current, as the operating voltage is raised to rated maximum voltage, for example from 11.5 kV up to 15 kV. The interrupting capability of vacuum circuit breakers is essentially constant over the entire range of operating voltages, up to and including its rated maximum voltage. The change was also made as a step toward harmonizing preferred ANSI ratings with the preferred ratings of IEC standards. It was further recognized that it is much simpler to select and apply circuit breakers rated on the basis of K = 1.0. The change in the K value, however, in no way affects the ratings and capabilities of circuit breakers originally tested and rated on the basis of K > 1 in the earlier editions of C37.06.

Existing circuit breakers, with ratings based on K > 1.0, are still valid and meet the latest editions of the standards. They should be continued to be applied as they have been in the past. The original K > 1.0 ratings are neither "obsolete" nor "inferior" to the new K = 1.0 ratings; they are just different. The new 1997 and 2000 editions of ANSI standard C37.06 still include the earlier K > 1 ratings as Table A1 and A1A. The change from K > 1.0 to K = 1.0 should be implemented by manufacturers as they develop and test new circuit breakers designs. The change does not require, recommend or suggest that manufactures re-rate and re-test existing breakers to new standard. And accordingly, Eaton continues to offer both circuit breakers rated on the traditional basis of K > 1.0 just as thousands of those breakers have been applied for variety of circuit switching applications worldwide. As Eaton develops new breakers, they are rated and tested to the new K = 1 ratings.

As a leader in vacuum interruption technology, Eaton continues to provide a wide choice of modern vacuum circuit breakers so the user can select the most economical circuit breaker to satisfy their circuit switching application.

- **Table 7.1-4** includes 5/15 kV circuit breakers rated on the basis of K = 1.0 in accordance with revised ANSI standards
- **Table 7.1-5** includes circuit breaker designs, rated on the basis of K = 1.0 with "extra capabilities" for those applications whose requirements go beyond what is usually experienced in normal distribution circuit applications
- **Table 7.1-6** and **Table 7.1-7** includes circuit breakers for special generator applications

Table 7.1-4. Available 5/15 kV VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards (Rated K = 1.0) (Continued Below)

Identification	Rated Values															
Drawout Circuit Breaker Type			Insulation Level			Short-Circuit Ratings (Reference C37.04-1999 and C37.06-2009 Except as Noted ①)										
											Transient Recovery Voltage Parameters are Based on TD-4					
	Maximum Voltage (V)	Power Frequency ①	Power Frequency Withstand Voltage (1 min.)	Lightning Impulse Withstand Voltage (1.2 x 50 µs)	Continuous Current	Symmetrical Interrupting Current (I) ②	dc Component (% dc) ③	Asymmetrical Interrupting Current (It) ④	Closing and Latching Current (2.6 x I)	Short-Time Withstand Current ⑤	Peak Voltage (E2) = (uc)	Time to Peak (T2 = t3 x 1.137)	TRV Rise Time (t3)	RRRV = uc/t3 ⑥	Interrupting Time	
Units	kV rms	Hz	kV rms	kV Peak	A rms	kA rms sym	%	kA rms asym Total	kA Peak	rms	kV Peak	µsec	µsec	kV/µsec	ms	Cycles (60 Hz)
50 VCP-W 25	4.76	60	19	60	1200	25	50	31	65	25	8.2	50	44	0.19	50	3
50 VCP-W 40	4.76	60	19	60	1200	40	50	49	104	40	8.2	50	44	0.19	50	3
50 VCP-W 50	4.76	60	19	60	1200	50	44	59	130	50	8.2	50	44	0.19	50	3
50 VCP-W 63	4.76	60	19	60	1200	63	55	80	164	63	8.2	50	44	0.19	50	3
150 VCP-W 25	15	60	36	95	1200 ⑦	25	50	31	65	25	28 ⑦	75	66	0.42	50	3
150 VCP-W 40	15	60	36	95	1200	40	50	49	104	40	25.7	75	66	0.39	50	3
150 VCP-W 50	15	60	36	95	1200	50	44	59	130	50	25.7	75	66	0.39	50	3
150 VCP-W 63	15	60	36	95	1200 ⑦	63	55	80	164	63	28 ⑦	75	66	0.42	50	3

① All circuit breakers are tested at 60 Hz; however, they can also be applied at 50 Hz with no derating.
② Because the voltage range factor K = 1, the short-time withstand current and the maximum symmetrical interrupting current are equal to the rated symmetrical interrupting current.
③ Based on the standard dc time constant of 45 ms (corresponding to X/R of 17 for 60 Hz) and the minimum contact parting time as determined from the minimum opening time plus the assumed minimum relay time of 1/2 cycle (8.33 ms for 60 Hz).
④ The asymmetrical interrupting current, I total, is given by (It) = I x Sqrt (1 + 2 x %dc x %dc) kA rms asymmetrical total.
⑤ Duration of short-time current and maximum permissible tripping delay are both 2 seconds for all circuit breakers listed in this table, as required in C37.04-1999, C37.06-2000 and C37.06-2009.
⑥ RRRV can also be calculated as = 1.137 x E2/T2.
⑦ These circuit breakers were tested to the preferred TRV ratings specified in C37.06-2000.

Table 7.1-4. Available VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards (Rated K = 1.0) (Continued)

Identification	Rated Values												
Drawout Circuit Breaker Type				Capacitance Current Switching Capability (Reference C37.04a-2003, C37.06-2009 and C37.09a-2005)								Out-of-Phase Switching	
								Back-to-Back Capacitor Switching					
	Continuous Current	Operating Duty	Mechanical Endurance	Cable-Charging Current		Isolated Shunt Capacitor Bank Current		Capacitor Bank Current		Inrush Current	Inrush Frequency	Voltage = 1.44 x V	Current = 0.25 x I
Units	A rms	Duty Cycle	No-Load Operations ⑧⑨	Class	A rms	Class	A rms	Class	A rms	kA Peak	kHz	kV rms	kA rms
50 VCP-W 25	1200	O—0.3s—CO—3m—CO	10,000	C2	3–10	C2	75–630	C2	75–630	6	0.8	7	6.3
50 VCP-W 40	1200	O—0.3s—CO—3m—CO	10,000	C2	3–10	C2	75–630	C2	75–630	6	0.8	7	10
50 VCP-W 50	1200	O—0.3s—CO—3m—CO	10,000	C2	3–10	C2	75–630	C2	75–630	6	0.8	7	12.5
50 VCP-W 63	1200	O—0.3s—CO—3m—CO	10,000	C2	7.5–25	C2	75–630	C2	75–630	6	0.8	7	15.8
150 VCP-W 25	1200	O—0.3s—CO—3m—CO	10,000	C2	7.5–25	C2	75–630	C2	75–630	6	0.8	22	6.3
150 VCP-W 40	1200	O—0.3s—CO—3m—CO	10,000	C2	7.5–25	C2	75–630	C2	75–630	6	0.8	22	10
150 VCP-W 50	1200	O—0.3s—CO—3m—CO	10,000	C2	7.5–25	C2	75–630	C2	75–630	6	0.8	22	12.5
150 VCP-W 63	1200	O—0.3s—CO—3m—CO	10,000	C2	7.5–25	C2	75–630	C2	75–630	6	0.8	22	15.8

⑧ Each operation consists of one closing plus one opening.
⑨ All 40 and 50 kA circuit breakers exceed required 5000 no-load operations; all 63 kA circuit breakers exceed the required 2000 no-load ANSI operations.

Industry Leader VCP-WC

The VCP-WC "extra capability" medium-voltage drawout circuit breaker is 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
- Glass-polyester (5/15 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.

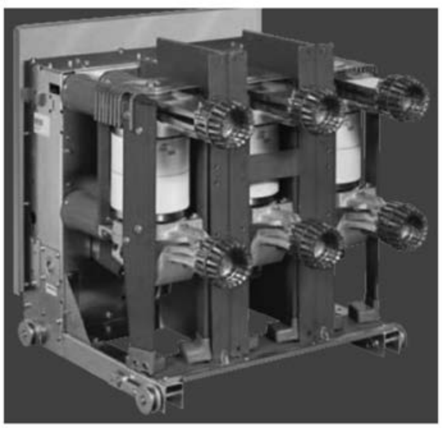
Table 7.1-5. Extra Capability Type VCP-WC Ratings (Symmetrical Current Basis), Rated K = 1

Identification	Rated Values																	Mechanical Endurance
Circuit Breaker Type	Voltage		Insulation Level			Current						Maximum Permissible Tripping Delay	Rate of Rise of Recovery Voltage (RRRV) ③	Capacitor Switching Ratings				
						Short-Circuit Current								General Purpose	Definite Purpose			
														Isolated Shunt Capacitor Bank Current	Back-to-Back Capacitor Switching			
	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	Sym. Interrupting at Voltage (Isc)	% dc Component (Idc)	Asym. Interrupting (It)	Closing and Latching Capability	Short-Time Current for 3 Seconds ①	Interrupting Time ②				Capacitor Bank Current	Inrush Current	Inrush Frequency	
	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	kA Peak	kHz	No-Load Operations
50 VCP-W 25C	5.95	1	24	75	1200	25	50	31	97	25	50	2.0	0.9	400 & 630	400 & 630	20 & 20	6.5 & 5.5	10,000
50 VCP-W 40C	5.95	1	24	75	1200	40	75	58	139	40	50	2.0	0.9	630	630	15	3.5	10,000
50 VCP-W 50C	5.95	1	24	75	1200	50	57	64	139	50	50	2.0	0.9	630	630	15	3.5	10,000
50 VCP-W 63C	5.95	1	24	75	1200	63	62	83	175	63	50	2.0	1.1	250	400 & 1600 ④	8.8 & 7.7	1.6 & 0.465	10,000
75 VCP-W 50C	10.3	1	42	95	1200	50	57	64	139	50	50	2.0	0.9	630	630	15	3.5	10,000
150 VCP-W 50C	17.5	1	42	95	1200	50	57	64	139	50	50	2.0	0.9	630 ⑤	630 ⑤	15	3.5	10,000
150 VCP-W 63C	15	1	42	95	1200	63	62	83	175	63	50	2.0	1.1	250	400 & 1600 ④	8.8 & 7.7	1.6 & 0.465	10,000

① Except as noted.
② 3 cycles.
③ Contact Eaton for higher RRRV or for more information.
④ C37.04.a-2003 Class C2 at 15 kV.
⑤ Capacitor Switching Ratings are proven at 15 kV. For sealed interrupters at high altitudes, switching voltage is not derated.

Type VCP-WG Generator Circuit Breakers

VCP-WG Breaker (Front View)



VCP-WG Breaker (Rear View)

Why generator circuit breakers?

- Specially rated generator breakers are typically used on generator applications 10,000 kW and above
- A generator circuit breaker, properly rated and tested to the appropriate industry standard, can protect the generator from damage, or even complete failure. Events such as feeding a faulted transformer, or when a fault should occur in the generator, are of particular concern

Generator circuits have unique characteristics that require specially designed and tested circuit breakers. The IEEE® developed the special industry standard C37.013 and amendment C37.013a-2007 to address these characteristics. Eaton has dedicated years of research, design, enhancement and testing to create Eaton's family of generator breakers.

The VCP-WG (drawout) and VCP-WRG (fixed) circuit breakers meet, and even exceed, the rigorous service duty requirements for generator circuit applications as defined by IEEE.

Eaton's VCP-WG and VCP-WRG generator breakers are available in two frame sizes. The 29.00-inch frame (29.00 inches wide with front cover on) is rated up to 15 kV, 63 kA and 3000 A (4000 A with forced-air cooling). The 31.00-inch frame (31.00 inches wide with front cover on) is rated up to 15 kV, 75 kA and 4000 A (5000 A with forced-air cooling). The 31.00-inch frame is also available in a fixed version with ratings up to 15 kV, 75 kA and 6000 A (7000 A with forced-air cooling).

Count on Eaton's innovative technology to handle high continuous ac current and voltage, then safely switch through extreme out-of-phase voltages and high-stress asymmetrical currents using vacuum interruption, without fail for over 10,000 normal operations.

Eaton's VCP-WG generator circuit breakers meet the strict service duty requirements set forth by IEEE for generator circuit applications, including:

- Generator circuit configuration
- High continuous current levels
- Unique fault current conditions
  - Transformer-fed faults
  - Generator-fed faults
- Unique voltage conditions
  - Very fast RRRV
  - Out-of-phase switching

Generator Circuit Configuration

The transformer and generator can be in close proximity to the circuit breaker. See **Figure 7.1-1**. Applications with high continuous current levels require connections with large conductors of very low impedance. This construction causes unique fault current and voltage conditions as shown in **Figure 7.1-2**.

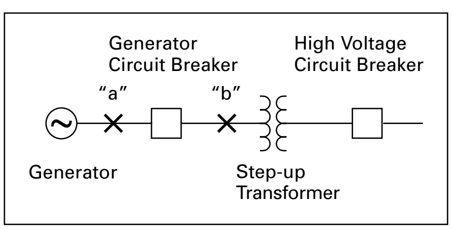


Figure 7.1-1. Generator Circuit Application

High Continuous Current Levels

Generator circuit breakers must be able to handle high continuous current levels without overheating. VCP-WG drawout circuit breakers are designed to reliably operate up to 4000 A with natural air convection cooling, and up to 5000 A with suitable enclosure fan cooling during overload conditions. VCP-WRG fixed circuit breakers are designed to reliably operate up to 6000 A with natural air convection cooling and up to 7000 A with suitable enclosure fan cooling during overload conditions.

Unique Fault Current Conditions

System-source (aka, transformer-fed) faults (see **Figure 7.1-1**, fault location "a") can be extremely high. The full energy of the power system feeds the fault, and the low impedance of the fault current path does very little to limit the fault current. Eaton's type VCP-WG Generator Circuit Breakers are ideal for interrupting such high fault currents because they have demonstrated high interruption ratings up to 75 kA, with high dc fault content up to 75%, as proven by high power laboratory tests.

Generator-source (aka, generator-fed) faults, see **Figure 7.1-1**, fault location "b") can cause a severe condition called "Delayed Current Zero," see **Figure 7.1-2**). The high ratio of inductive reactance to resistance (X/R ratio) of the system can cause the dc component of the fault current to exceed 100%. The asymmetrical fault current peak becomes high enough and its decay becomes slow enough that the natural current zero is delayed for several cycles. The circuit breaker experiences longer arcing time and more electrical, thermal and mechanical stress during the interruption. The IEEE standard requires verification that the circuit breaker can interrupt under these severe conditions. Eaton's VCP-WG generator circuit breakers have demonstrated their ability to interrupt three-phase fault current levels up to 135% dc content under delayed current zero conditions.

Unique Voltage Conditions

Generator circuits typically produce very fast rates of rise of recovery voltage (RRRV) due to the high natural frequency and low impedance and very low stray capacitance. VCP-WG generator circuit breakers are designed to interrupt fault current levels with very fast RRRV in accordance with IEEE standard C37.013 and C37.013a. VCP-WG generator circuit breakers have a distinct ability to perform under out-of-phase conditions when the generator and power system voltages are not in sync. The voltages across the open contacts can be as high as twice the rated line-to-ground voltage of the system. The IEEE standard requires demonstration by test that the generator circuit breaker can switch under specified out-of-phase conditions.

Versatility in Application

Eaton's generator vacuum circuit breakers are available in drawout (VCP-WG) or fixed (VCP-WRG) configurations to provide for superior performance and versatility. Many industrial and commercial power systems now include small generators as a local source of power. New applications are arising as a result of the de-regulation of the utility industry, and the construction of smaller packaged power plants. Eaton's generator breakers interrupt large short-circuit currents in a small three-pole package.

Typical applications include:

- Electric utilities: fossil, hydro and wind power
- Packaged power plants
- Industrial companies using combined cycle/combustion turbine plants
- Government and military
- Commercial institutions
- Petrochemical and process industries
- Forestry, pulp and paper
- Mining, exploration and marine

The VCP-WG is the world's generator circuit breaker for reliable and robust power generation protection.

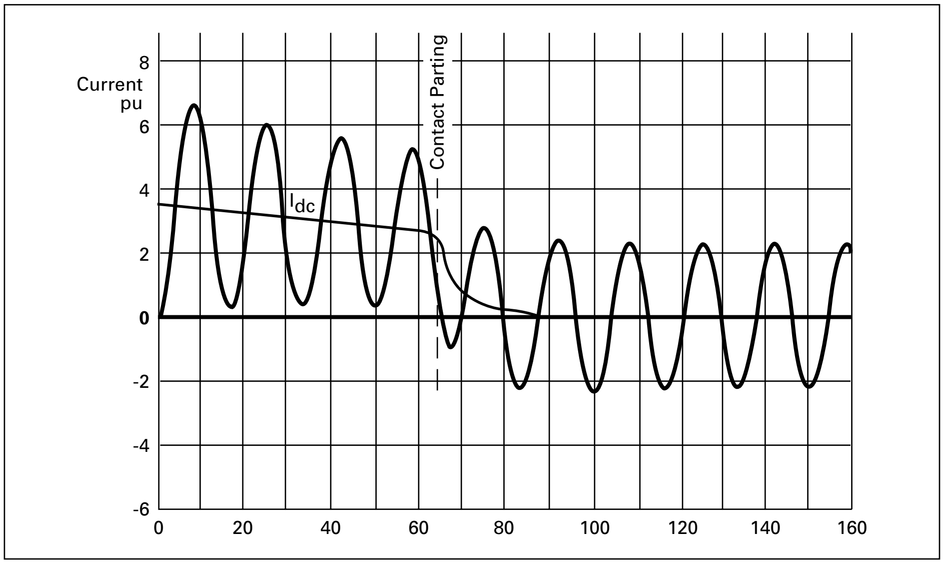


Figure 7.1-2. Generator-Fed Faults Can Experience Delayed Current Zero, Where the High Inductance to Resistance Ratio of the System Can Cause the dc Component of the Fault Current to Exceed 100%

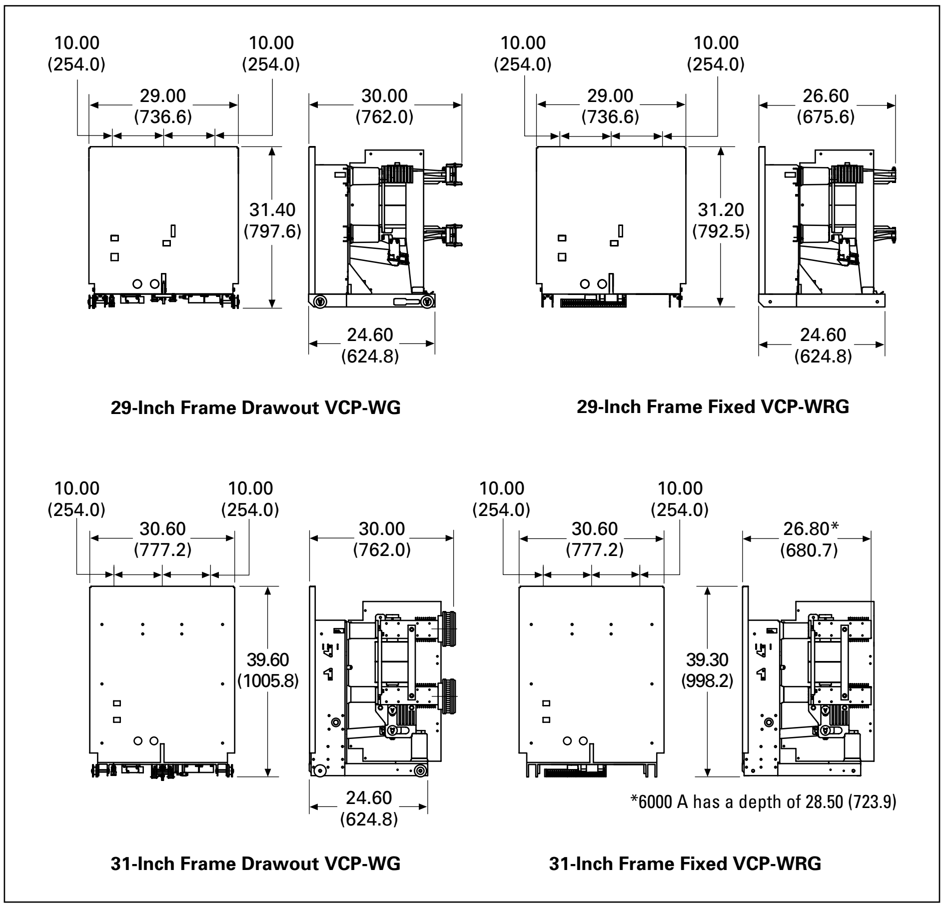


Figure 7.1-3. Type VCP-WG (Drawout) and Type VCP-WRG (Fixed) Circuit Breakers

5 kV Class Generator Circuit Breaker Ratings

Table 7.1-6. Generator Circuit Breaker Types: VCP-WG (Drawout—DO) / VCP-WRG (Fixed—FIX)

Description	Units	Short-Circuit Current (Isc)					
		50 kA		63 kA		75 kA	
Maximum Voltage (V): 5 kV							
Frame in Inches (mm)	—	29.00 (736.6)	29.00 (736.6)	29.00 (736.6)	29.00 (736.6)	31.00 (787.4)	31.00 (787.4)
Ratings Assigned	—	DO	FIX	DO	FIX	DO	FIX
Continuous Current	A rms	1200	1200	1200	1200	1200	1200
Dielectric Strength Power frequency withstand voltage Lightning impulse withstand voltage	 kV rms kV peak	 19 60	 19 60	 19 60	 19 60	 19 60	 19 60
Interrupting Time	ms	50	50	50	50	83	83
Closing Time	ms	47	47	47	47	47	47
Short-Circuit Current Asymmetrical current interrupting capability Ref: Minimum opening time Short-time current carrying capability Duration of short-time current	kA rms % dc ms kA rms sec	50 75 30 50 3	50 75 30 50 3	63 75 30 63 3	63 75 30 63 3	75 63 54 75 1	75 63 54 75 1
Closing and Latching Capability	kA peak	137	137	173	173	206	206
First Generator-Source Symmetrical Current Interrupting Capability	kA rms	25	25	31.5	31.5	40	40
First Generator-Source Asymmetrical Current Interrupting Capability	% dc	130	130	130	130	130	130
Second Generator-Source Symmetrical Current Interrupting Capability	kA rms	—	—	40	40	50	50
Second Generator-Source Asymmetrical Current Interrupting Capability	% dc	—	—	110	110	110	110
Prospective TRV—Rate of Rise of Recovery Voltage (RRRV) Transient recovery voltage—Peak (E2 = 1.84 x V)	kV / µs kV peak	3.0 9.2	3.0 9.2	3.0 9.2	3.0 9.2	3.0 ① 9.2 ①	3.0 ① 9.2 ①
Transient recovery voltage—Time to Peak (T2 = 0.62 x V)	µs	3.1	3.1	3.1	3.1	3.1 ①	3.1 ①
Load Current Switching Endurance Capability	Operations	10,000	10,000	10,000	10,000	10,000	10,000
No-Load Mechanical Endurance Capability	Operations	10,000	10,000	10,000	10,000	10,000	10,000
Out-of-Phase Current Switching Capability	kA	25	25	31.5	31.5	37.5	37.5
90° out-of-phase power frequency recovery voltage (= 1.5 x sqrt(2/3) x V)	kV rms	6.1	6.1	6.1	6.1	6.1	6.1
90° out-of-phase inherent TRV—Rate of Rise of Recovery Voltage (RRRV)	kV / µs	3.3	3.3	3.3	3.3	3.3	3.3
Transient recovery voltage—Peak (E2 = 2.6 x V)	kV peak	13	13	13	13	13	13
Transient recovery voltage—Time to Peak (T2 = 0.89 x V)	µs	4.5	4.5	4.5	4.5	4.5	4.5

① TRV capacitors are required if RRRV is >0.5 kV/µs; or T2 is <65 µs.

Note: Rated frequency: 60 Hz.

Note: Standard operating duty: CO - 30 m - CO.

Note: Relevant Standard: IEEE standards C37.013-1997 and C37.013a-2007.

Note: Test certificates available.

15 kV Class Generator Circuit Breaker Ratings

Table 7.1-7. Generator Circuit Breaker Types: VCP-WG (Drawout—DO) / VCP-WRG (Fixed—FIX)

Description	Units	Short-Circuit Current (Isc)					
		50 kA		63 kA		75 kA	
Maximum Voltage (V): 15 kV							
Frame in Inches (mm)	—	29.00 (736.6)	29.00 (736.6)	29.00 (736.6)	29.00 (736.6)	31.00 (787.4)	31.00 (787.4)
Ratings Assigned	—	DO	FIX	DO	FIX	DO	FIX
Continuous Current	A rms	1200	1200	1200	1200	1200	1200
Dielectric Strength Power frequency withstand voltage Lightning impulse withstand voltage	 kV rms kV peak	 36 95	 36 95	 36 95	 36 95	 36 95	 36 95
Interrupting Time	ms	50	50	50	50	83	83
Closing Time	ms	47	47	47	47	47	47
Short-Circuit Current Asymmetrical current interrupting capability Ref: Minimum opening time Short-time current carrying capability Duration of short-time current	kA rms % dc ms kA rms s	50 75 30 50 3	50 75 30 50 3	63 75 30 63 3	63 75 30 63 3	75 63 54 75 1	75 63 54 75 1
Closing and Latching Capability	kA peak	137	137	173	173	206	206
First Generator-Source Symmetrical Current Interrupting Capability	kA rms	25	25	31.5	31.5	40	40
First Generator-Source Asymmetrical Current Interrupting Capability	% dc	130	130	130	130	130	130
Second Generator-Source Symmetrical Current Interrupting Capability	kA rms	—	—	40	40	50	50
Second Generator-Source Asymmetrical Current Interrupting Capability	% dc	—	—	110	110	110	110
Prospective TRV—Rate of Rise of Recovery Voltage (RRRV) Transient recovery voltage—Peak (E2 = 1.84 x V)	kV / µs kV peak	3.4 27.6	3.4 27.6	3.4 27.6	3.4 27.6	3.4 ① 30.9 ①	3.4 ① 30.9 ①
Transient recovery voltage—Time to Peak (T2 = 0.62 x V)	µs	9.3	9.3	9.3	9.3	9.3 ①	9.3 ①
Load Current Switching Endurance Capability	Operations	10,000	10,000	10,000	10,000	10,000	10,000
No-Load Mechanical Endurance Capability	Operations	10,000	10,000	10,000	10,000	10,000	10,000
Out-of-Phase Current Switching Capability	kA	25	25	31.5	31.5	37.5	37.5
90° out-of-phase power frequency recovery voltage (= 1.5 x sqrt(2/3) x V)	kV rms	18.4	18.4	18.4	18.4	18.4	18.4
90° out-of-phase inherent TRV—Rate of Rise of Recovery Voltage (RRRV)	kV / µs	3.3	3.3	3.3	3.3	3.3	3.3
Transient recovery voltage—Peak (E2 = 2.6 x V)	kV peak	39	39	39	39	39	39
Transient recovery voltage—Time to Peak (T2 = 0.89 x V)	µs	13.4	13.4	13.4	13.4	13.4	13.4

① TRV capacitors are required if RRRV is >0.5 kV/µs; or T2 is <65 µs.

Note: Rated frequency: 60 Hz.

Note: Standard operating duty: CO - 30 m - CO.

Note: Relevant Standard: IEEE standards C37.013-1997 and C37.013a-2007.

Note: Test certificates available.

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 7.1-8**. **Figure 7.1-4** below shows the sequence of events in the course of circuit interruption, along with applicable VCP-W circuit breaker timings.

Table 7.1-8. Closing Time and Opening Time

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

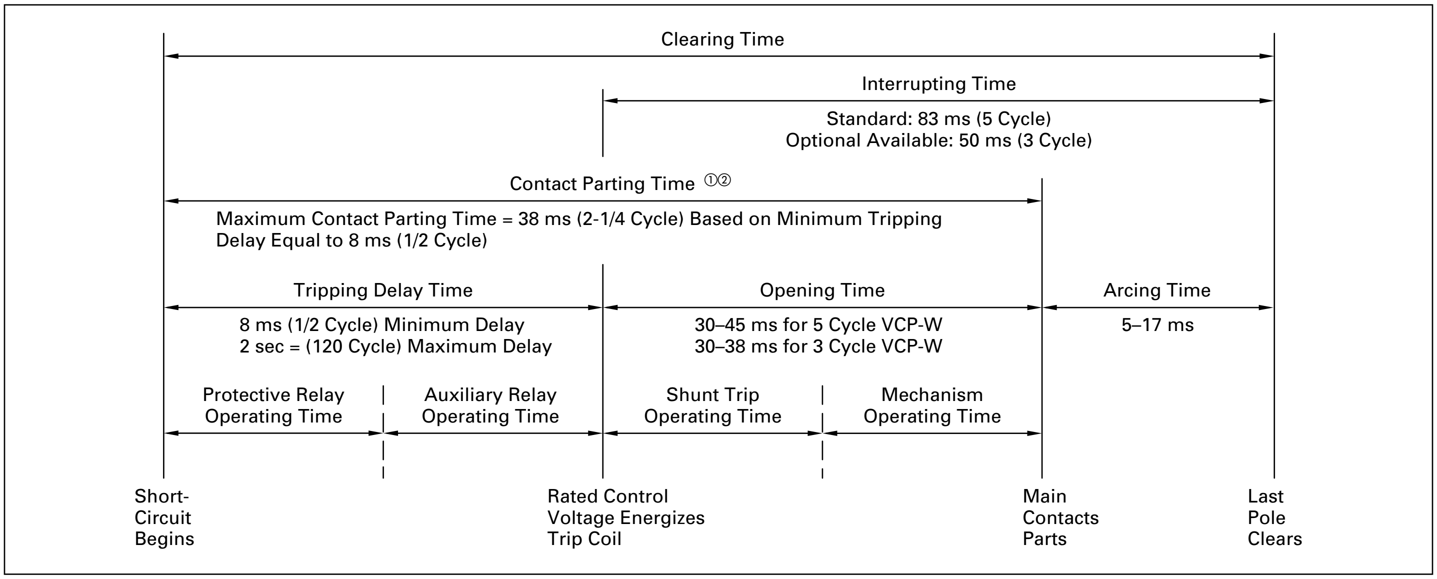


Figure 7.1-4. Sequence of Events and Circuit Breaker Operating Times

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.

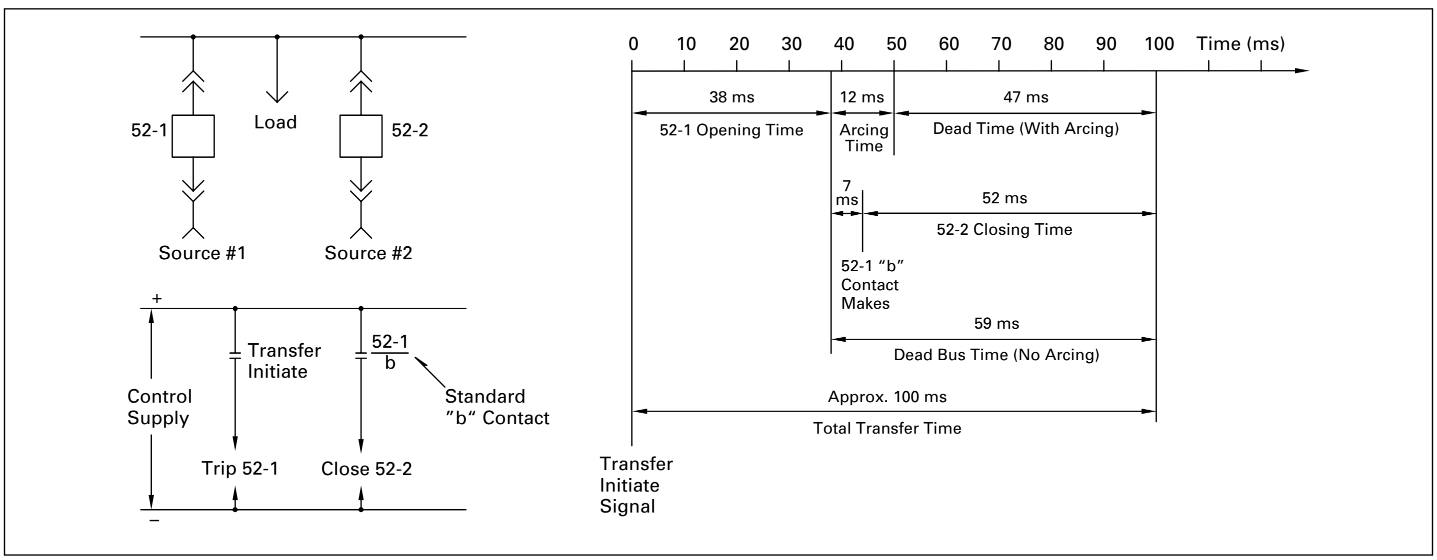


Figure 7.1-5. Typical Transfer Times ③—Fast Sequential Transfer

③ Times shown are based on 60 Hz.

Protection Relays

Overcurrent Protection

Eaton's MEB breaker can be furnished with an Eaton Type EDR-3000 or EDR-5000 relay to provide overcurrent and fault protection. Optional zero sequence 50/51G ground fault protection is shown below.

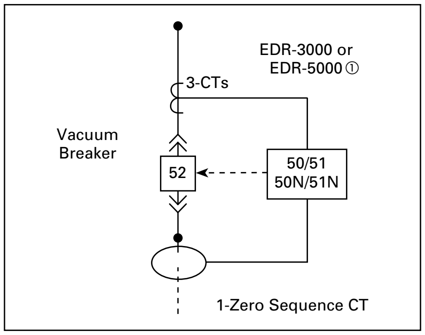


Figure 7.1-6. Typical MEB Single-Section One-Line Diagram

① Use of EDR-5000 requires VTs.

EDR-3000 Overcurrent Protective Relay

EDR-5000 Multifunction Protective Relay

Table 7.1-9. Protective Relays

Relay Type	Protective Relay IEEE Functions	Metering
EDR-3000	50/51; 50/51G	Amperes and ampere demand
EDR-5000	25, 27, 32, 46, 47, 50N/G, 51N/G, 50/51,50BF, 51V, 59, 67N, 67	Amps; volts; pf, energy, power;THD; waveform

System Options

Surge Arresters

IEEE Standard C62.11 for metal-oxide surge arresters lists the maximum rated ambient temperature as 40 °C. The ambient temperature inside an MEB switchgear vertical section may exceed this temperature, especially in outdoor applications where solar radiation may produce a significant contribution to the temperature. **Table 7.1-10** lists the recommended minimum duty cycle rating for various system grounding methods based on switchgear temperatures not exceeding 55 °C.

Table 7.1-10. Suggested Minimum Ratings (kV) for Metal-Oxide Surge Arresters Located in Metal-Enclosed Switchgear

Service Voltage Line-to-Line kV	Distribution Class Arresters						Station Class Arresters					
	Solidly Grounded System		Low Resistance Grounded System		High Resistance or Ungrounded System		Solidly Grounded System		Low Resistance Grounded System		High Resistance or Ungrounded System	
	Arrester Ratings kV						Arrester Ratings kV					
	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV
2.30	3	2.55	3	2.55	3	2.55	3	2.55	3	2.55	3	2.55
2.40	3	2.55	3	2.55	6	5.10	3	2.55	3	2.55	6	5.10
3.30	3	2.55	3	2.55	6	5.10	3	2.55	3	2.55	6	5.10
4.00	3	2.55	6	5.10	6	5.10	3	2.55	6	5.10	6	5.10
4.16	6	5.10	6	5.10	6	5.10	6	5.10	6	5.10	6	5.10
4.76	6	5.10	6	5.10	9	7.65	6	5.10	6	5.10	9	7.65
4.80	6	5.10	6	5.10	9	7.65	6	5.10	6	5.10	9	7.65
6.60	6	5.10	6	5.10	9	7.65	6	5.10	6	5.10	9	7.65
6.90	6	5.10	6	5.10	9	7.65	6	5.10	9	7.65	9	7.65
7.20	6	5.10	6	5.10	10	8.40	6	5.10	9	7.65	10	8.40
8.32	9	7.65	9	7.65	12	10.20	9	7.65	9	7.65	12	10.20
8.40	9	7.65	9	7.65	12	10.20	9	7.65	9	7.65	12	10.20
11.00	9	7.65	9	7.65	15	12.70	9	7.65	10	8.40	15	12.70
11.50	9	7.65	10	8.40	18	15.30	9	7.65	12	10.20	18	15.30
12.00	10	8.40	10	8.40	18	15.30	10	8.40	12	10.20	18	15.30
12.47	10	8.40	12	10.20	18	15.30	10	8.40	12	10.20	18	15.30
13.20	12	10.20	12	10.20	18	15.30	12	10.20	12	10.20	18	15.30
13.80	12	10.20	12	10.20	18	15.30	12	10.20	15	12.70	18	15.30
14.40	12	10.20	12	10.20	21	17.00	12	10.20	15	12.70	21	17.00

Note: MCOV = Maximum Continuous Operating Voltage.

MEB Switchgear with Automatic Transfer Control

Application

Eaton's MEB switchgear with an automatic transfer control system is an integrated assembly of drawout VCP-W breakers, sensing devices and control components. Available in 5–15 kV classes.

It is typically applied where the continuity of service for critical loads from two power sources in either a two-breaker (one bus) or three-breaker (two bus) configuration is desired.

MEB switchgear with an automatic transfer control system can meet most automatic throwover requirements and has a wide variety of operational sequences embodied in one standard automatic transfer control system.

Typical Two-Breaker Automatic Transfer Using ATC Controller

Eaton's ATC-900 controller continuously monitors all three phases on both sources for correct parameters. Should the normal source be lost while the alternate source remains available, the sensing function in the ATC controller will change state starting the time delay function. If the of the normal source is not restored by the end of the time delay interval, the normal breaker will open and the alternate source breaker will close, restoring power to the load.

ATC Controller

Eaton's ATC-900 controller is equipped to display historical information via the front panel or over the power monitoring system. The ATC-900 controller stores 320 time stamped events. Oscillographic data for last 10 events can be downloaded via a USB port or displayed in the controller's display window. The controller allows communication via RS-232 or Modbus through an RS-458 port, Ethernet or via a USB interface.

ATC Controller

Standard Features

- Voltage sensing on both sources is provided by the ATC controller
- Lights to indicate status of switches, sources, and so forth
- Interlocking to prevent paralleling of sources via software
- Control power for the automatic transfer control system is derived from the sensing transformers
- Manual override operation
- Selectable closed with sync check or open transition on return to normal
- Programmable time delays on both sources, "OFF DELAY" and "ON DELAY"
- Four programmable digital inputs and outputs
- Single-source responsibility; all basic components are manufactured by Eaton

Optional Features

- Lockout on phase and/or ground overcurrents and/or internal bus faults
- Load current, power and PF metering with optional DCT module
- 24 Vdc control power input
- Up to four additional I/O modules each with four programmable digital inputs and digital outputs

Typical Three-Breaker (Two Mains and Normally Open Tie) Automatic Transfer Control

The automatic transfer switchgear assembly includes two main breakers and one tie breaker. An integrated automatic transfer control system containing sensing devices and low-voltage logic control and auxiliary equipment are also included. The transfer control system monitors both sources for correct parameters. A transfer selector switch is provided for selection between manual or automatic operating mode. In manual mode, all three breakers are manually operated. Electrical interlocking is provided in manual mode to prevent closing all three breakers at the same time. In automatic mode, the sequence of operation is based on two normally energized sources and operates as follows. Normal operation is: main breakers closed and the tie breaker open. Upon detecting an undervoltage(s) on the line side of a main breaker, and after a field-adjustable time delay, that main breaker opens. After an additional field-adjustable time delay, the tie breaker closes to restore power to the affected portion of the facility. Upon restoration of power to the line side of the main breaker, and after a field-adjustable time delay, the tie breaker opens. After a field-adjustable time delay, the opened main breaker closes.

Partial Discharge Sensing and Monitoring for Switchgear

Coupling Capacitor Type PD Sensor

RFCT Sensor

InsulGard Relay (PD Monitoring)

Partial Discharge in Switchgear

Partial discharge (PD) 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 high-frequency discharges are essentially small arcs occurring in or on the surface of the insulation system when 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 the insulation becomes deteriorated. Examples of partial discharges 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 activity 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 MEB metal-enclosed switchgear (2.4–15 kV) is corona-free by design. 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 4000 V and above. Type MEB switchgear can be equipped with factory-installed partial discharge sensors and a partial discharge sensing relay for continuous monitoring under normal operation. Timely detection of insulation degradation through increasing partial discharges can identify potential problems so corrective action 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 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 MEB switchgear compartments are detected by the installation of a small donut type radio frequency current transformer (RFCT) sensors over floating stress shields of the specially designed bus or line side primary bushings. Partial discharge in power cables (external discharges) is detected by the installation of RFCTs around the ground shields of incoming or outgoing power cable terminations.

Output signals from sensors (coupling capacitor and RFCT) are wired out to terminal blocks for future or field use, or connected to the InsulGard relay. One InsulGard relay can monitor up to 15 input signals, as well as temperature and humidity. The temperature and humidity sensors are included with each InsulGard relay system. The relay continuously monitors the switchgear primary system for partial discharges and provides an alarm signal (contact closure) when high PD level is detected. Also, data analysis and diagnostics performed by Eaton engineers can be provided by remote communication with the InsulGard relay.

The sensors and InsulGard relay are optional in MEB switchgear.

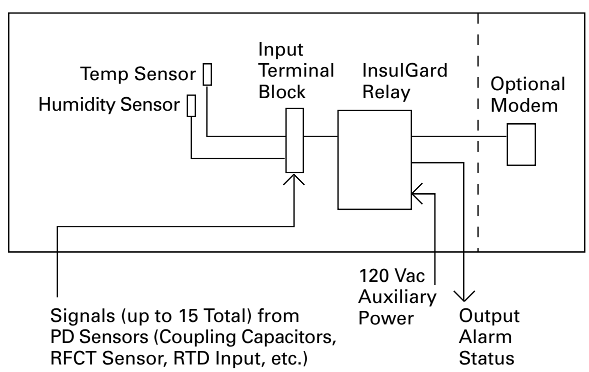
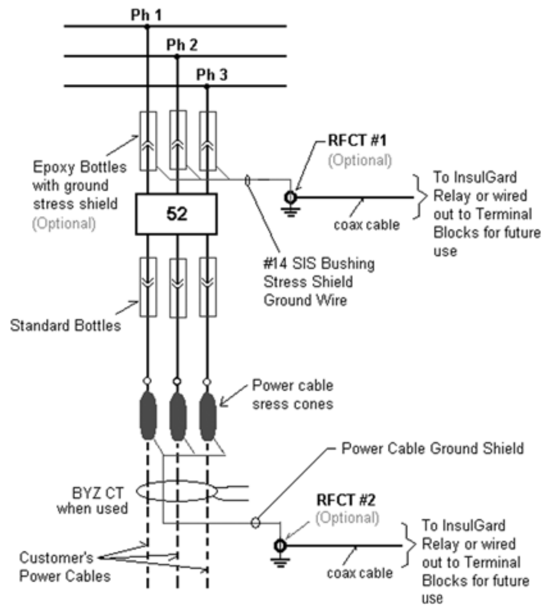


Figure 7.1-7. InsulGard Relay System

Partial Discharge Sensors and Monitoring for Switchgear



RFCT #1 detects partial discharges internal to switchgear compartment.

RFCT #2 detects partial discharges in customer's cables up to 100 ft from switchgear.

Figure 7.1-8. Typical Partial Discharge Sensor Connections in MEB Switchgear (5–15 kV)

Note: Use one set of epoxy bottles with ground stress shield on bus side (either in the top or bottom compartment) at every two vertical sections. Use standard bottles at all other locations.

Standard

Typical Arrangements—5 kV and 15 kV

The sketches in this section represent the most common arrangements. Layouts shown are for rear-accessible equipment. Front-accessible designs are available—refer to Eaton. Many other configurations and combinations are available. Two voltage transformers (fixed or drawout) for metering or one control transformer for AC breaker control can be mounted in the structures shown. For control power above 1 kVA, additional space is required.

Depth of units will vary due to cable entrance and exit requirements, the addition of lightning arresters, instrument transformers, special cable terminators, and so on. Cables are shown as bottom or top entry only. Top or bottom must be selected for incoming and outgoing cables. Please note that rear access is required for installation. Cable sizing is based on **two** 500 kcmil XLP or EPR insulated **cables per phase** using preformed slip-on cable termination devices.

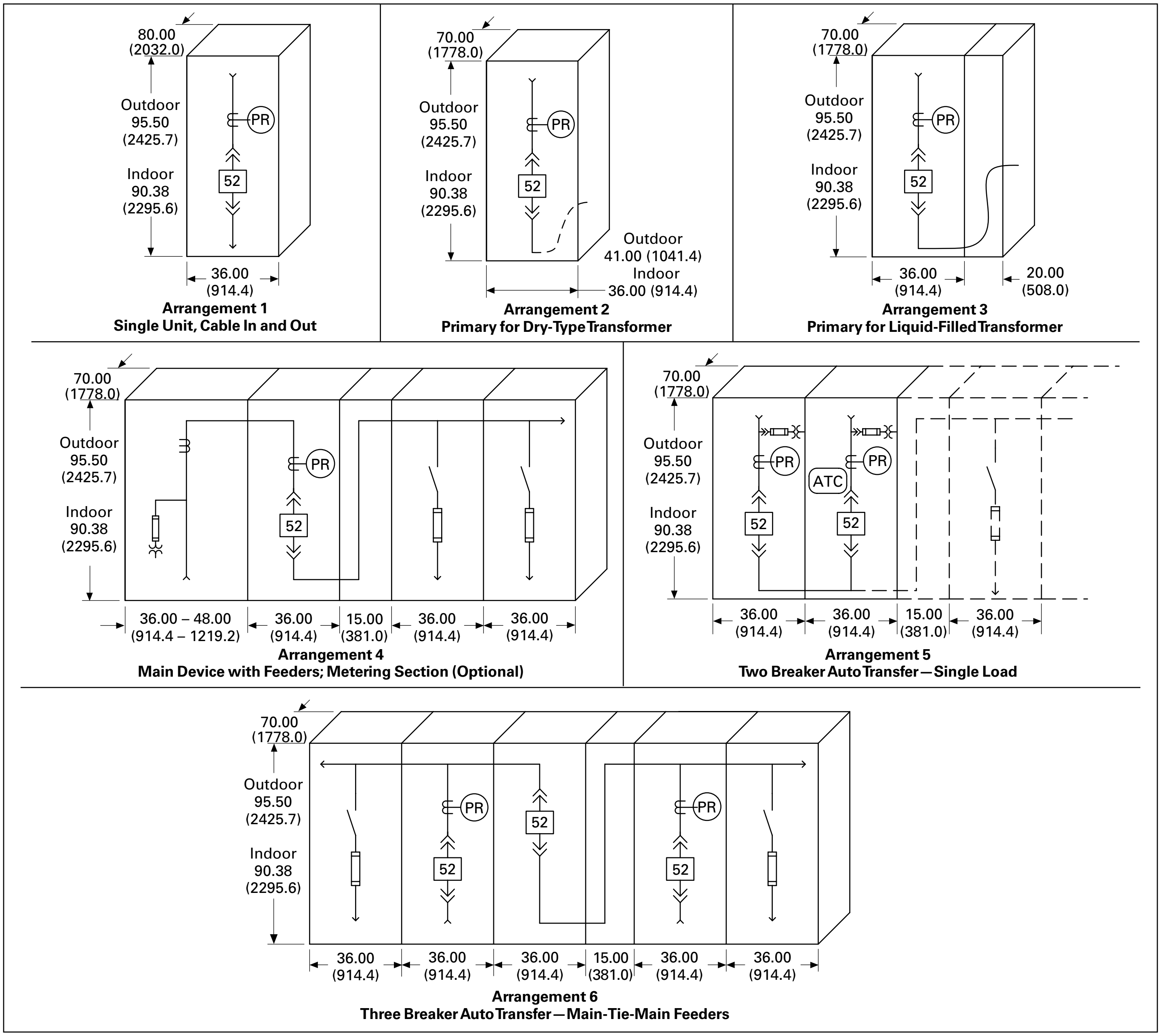


Figure 7.1-9. Typical Arrangements—5 kV and 15 kV — Dimensions in Inches (mm)

Note: PR—Overcurrent protective relay, typical functions—50/51, 50/51N or 50/51G. Eaton EDR-3000 or EDR-5000.

Note: ATC—Automatic Transfer Controller.

Dimensions in inches (mm). Not to be used for construction purposes unless approved.

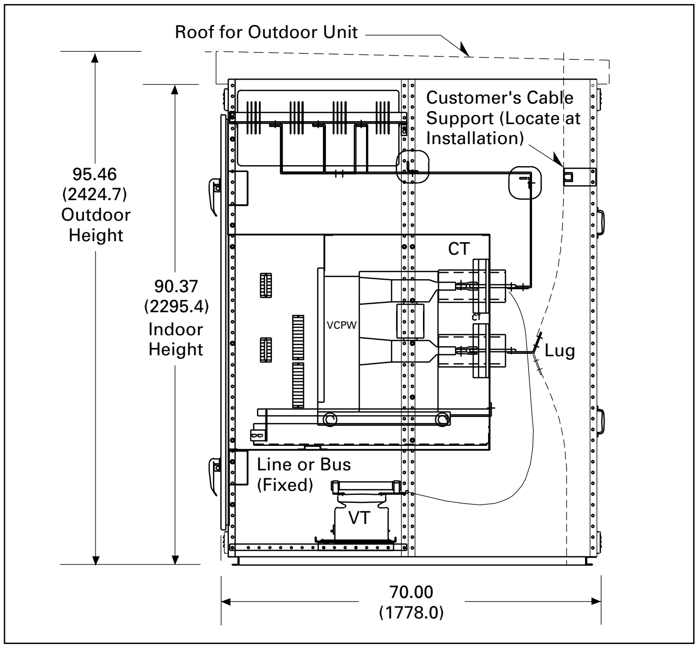


Figure 7.1-10. 5 and 15 kV MEB with Main Bus, Main Breaker and Fixed Line or Bus VTs

① Depth shown is based on the use of (2)-500 kcmil cables per phase. For stand-alone cable in and cable out in the same section, minimum 80.00-inch (2032.0 mm) depth is required.

Note: Drawout VTs are not available in MEB switchgear. Use Type VCP-W or MEF designs.

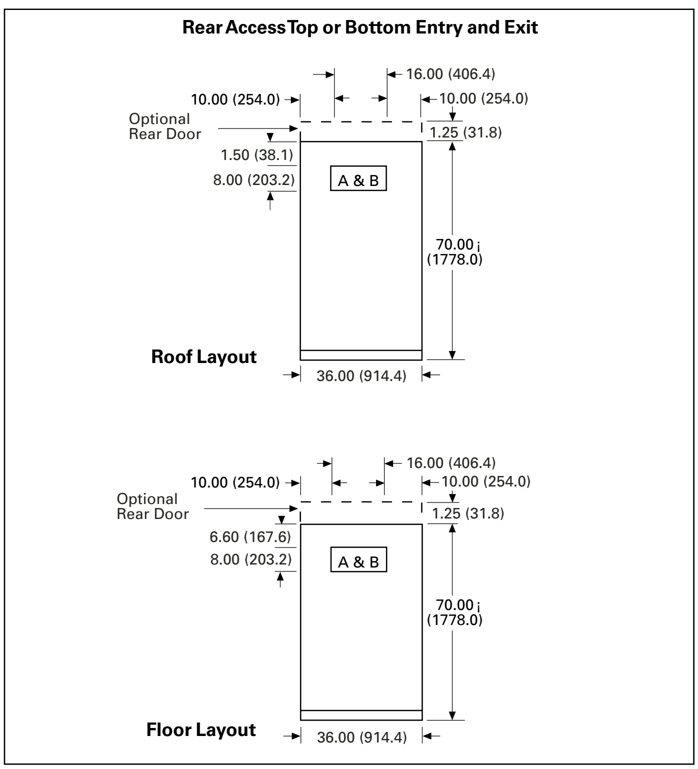


Figure 7.1-11. 5 and 15 kV Roof Layouts and Floor Layouts

② For cable in and cable out in same section, 80.00-inch (2032.0 mm) depth is required.

Note: A = Power cable to load, B = Power cable from source.

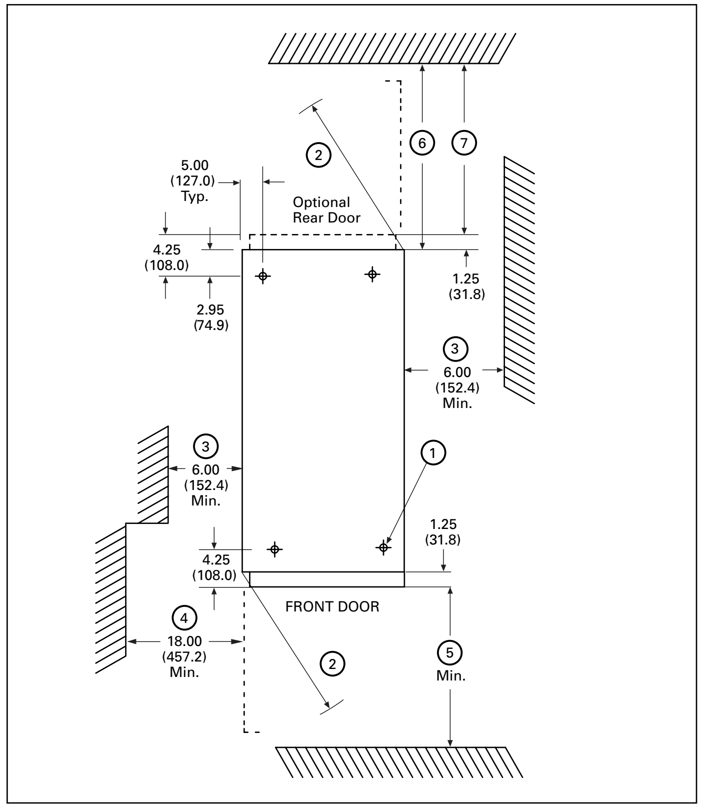


Figure 7.1-12. Typical Anchor Plan for MEB, Indoor or Outdoor

① Locations for tie-down 0.65 (16.5 mm) diameter holes. Four places. Customer provided bolts for anchoring should be 0.50–13 min. SAE Grade 5, (M12 x 1.75 min. CL 10.9), and tightened to 75 ft-lb (101.7 Nm).

② Door swing equals unit width at 90°.

③ The standard minimum clearances on side. The authority having jurisdiction may require a larger distance.

④ Clearance required for additional door swing to insert or remove breaker, and for metering/relays on front of door. Left hand side only. The authority having jurisdiction may require a larger distance.

⑤ Minimum distance in front is 72.00 inches (1828.8 mm) for breaker insertion and removal. The authority having jurisdiction may require a larger distance.

⑥ The standard minimum recommended distance is 30.00 inches (762.0 mm) for assemblies requiring rear access for installation and maintenance. The authority having jurisdiction may require a larger distance.

⑦ If optional rear door is supplied, the minimum is the width of the widest vertical section plus 1.00 inch (25.4 mm). The authority having jurisdiction may require a larger distance.

⑧ Finished foundation's surface shall be level within 0.06-inch (1.5 mm) in 36.00 inches (914.4 mm) left-to-right, front-to-back and diagonally, as measured by a laser level.

Application Examples

Low Resistance Ground Schemes

Medium-voltage low-resistance ground schemes are typically used for 5 kV class systems feeding 5 kV class motor loads. The resistor affords both full selectivity in tripping on ground faults, while limiting ground fault magnitudes to low values (typically 50–400 A). Reducing the current levels to a faulted motor greatly reduces damage and subsequent rewind and repair costs.

System tripping during ground faults on the line side of the secondary main breaker must be cleared by sending a trip signal to the transformer primary side protective device. Fusible switches on the primary side of the step-down transformer (typically rated 5–15 kV) may not be used for this purpose. Any ground fault sensed may escalate as the switch is being signaled to trip, thereby exceeding its typical 600 A maximum current breaking capacity.

Eaton's MEB breaker, being a fully rated interrupting device, may be tripped regardless of fault level up to its interrupting rating (for example, 28 kA). Only this type of overcurrent device or a metal-clad switchgear drawout breaker may be safely used.

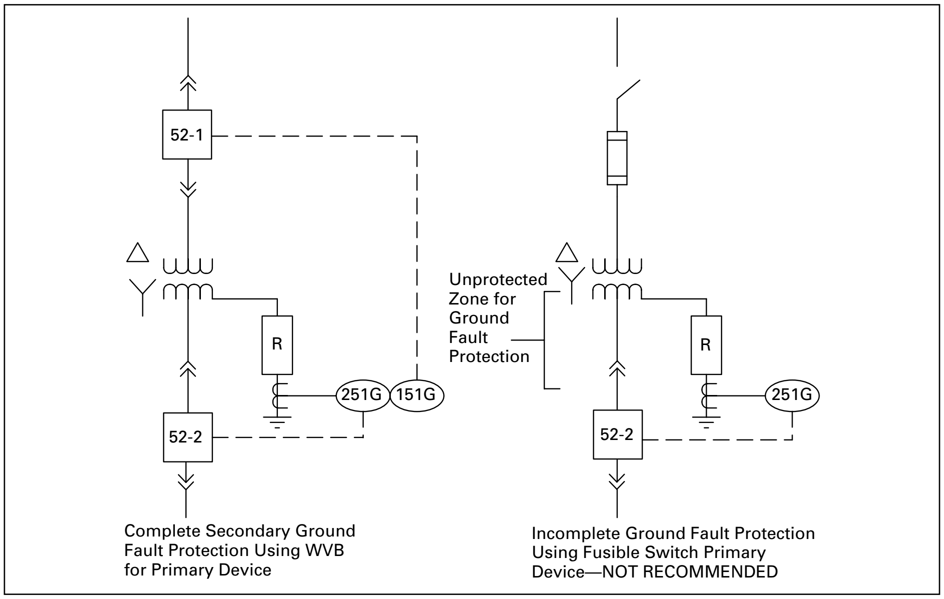


Figure 7.1-13. Low Resistance Ground Scheme (Phase and Primary Ground Fault Protection not Shown)

Single-Ended Substation Designs

In this configuration, the MEB serves as both primary and secondary protection for the transformer. Savings in both floor space and cost result, due to elimination of the secondary main device. This scheme is only recommended where cost and space prevent the use of a secondary main device.

Note: Two sets of current transformers are used to protect against secondary ground faults, overloads and short circuits, as well as primary winding faults.

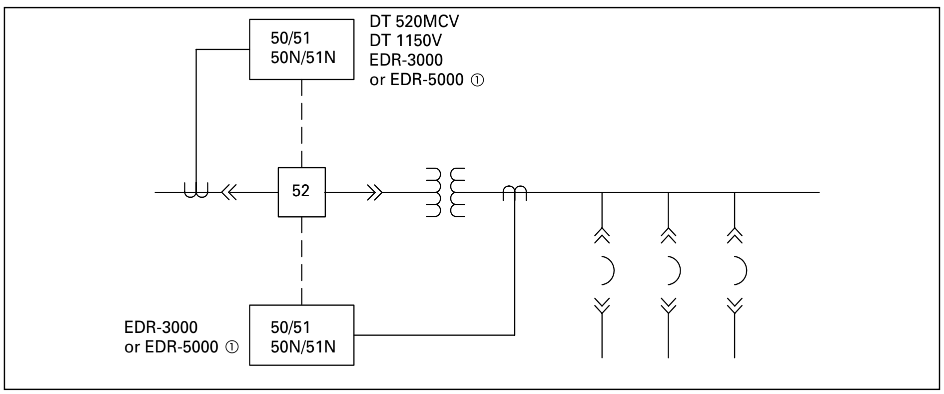


Figure 7.1-14. Single-Ended Unit Substations Using Primary Breaker Protection (MEB)

① Use of DT-1150V or EDR-5000 requires VTs.

Weights

Table 7.1-11. Approximate Weights in Lb (kg)

5 or 15 kV Class	Indoor	Outdoor
MEB section	1600 (726)	1900 (863)
MVS section (non-fused)	1500 (681)	1800 (817)
Fuses (three) add	200 (91)	200 (91)
Transition section	300 (136)	—

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