

FA-VR, FB-VR, & FC-VR Replacement Circuit Breaker



FC-VR 500 1200A Shown



Powering Business Worldwide

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THE CIRCUIT BREAKERS DESCRIBED IN THIS BOOK ARE DESIGNED AND TESTED TO OPERATE WITHIN THEIR NAMEPLATE RATINGS. OPERATION OUTSIDE OF THESE RATINGS MAY CAUSE THE EQUIPMENT TO FAIL, RESULTING IN DEATH, BODILY INJURY AND PROPERTY DAMAGE.

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This product was manufactured by Eaton at the Power Breaker Center (PBC): 310 Maxwell Avenue, Greenwood, SC 29646.

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of particular equipment, contact an Eaton representative.

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SECTION 1: INTRODUCTION

The purpose of this book is to provide instructions for receiving and handling, storage, installation, operation and maintenance of the Allis-Chalmers type FA, FB, & FC (F-Series) VR-Series circuit breaker. The Vacuum Replacement Circuit Breakers (also referred to as VR-Series) are designed to be used in existing Allis-Chalmers type F-Series metal-enclosed switchgear and provide equal of superior electrical and mechanical performance as compared to the design ratings of the original circuit breaker. VR-Series Circuit Breakers provide reliable control, protection and performance, with ease of handling and maintenance. Like ratings are interchangeable with each other.

This book is intended to be used in conjunction with the technical information provided with the original equipment order which includes, but is not limited to electrical control schematics and wiring diagrams, outline diagrams, installation plans, and procedures for installation and maintenance of accessory items.

Satisfactory performance is dependant upon proper application, correct installation, and adequate maintenance. It is strongly recommended that this instruction book be carefully read and followed in order to realize optimum performance and long useful life of the circuit breaker.

⚠ WARNING

SATISFACTORY PERFORMANCE OF THESE BREAKERS IS CONTINGENT UPON PROPER APPLICATION, CORRECT INSTALLATION AND ADEQUATE MAINTENANCE. THIS INSTRUCTION BOOK MUST BE CAREFULLY READ AND FOLLOWED IN ORDER TO OBTAIN OPTIMUM PERFORMANCE FOR LONG USEFUL LIFE OF THE CIRCUIT BREAKERS. IT IS FURTHER RECOMMENDED THAT THE INSTALLATION BE PERFORMED BY A EATON CORPORATION TRAINED ENGINEER OR TECHNICIAN.

VR-SERIES BREAKERS ARE PROTECTIVE DEVICES, AS SUCH, THEY ARE MAXIMUM RATED DEVICES. THEREFORE, THEY SHOULD NOT UNDER ANY CIRCUMSTANCE BE APPLIED OUTSIDE THEIR NAMEPLATE RATINGS.

ALL POSSIBLE CONTINGENCIES WHICH MIGHT ARISE DURING INSTALLATION, OPERATION, OR MAINTENANCE, AND ALL DETAILS AND VARIATIONS OF THIS EQUIPMENT ARE NOT COVERED BY THESE INSTRUCTIONS. IF FURTHER INFORMATION IS DESIRED BY THE PURCHASER REGARDING A PARTICULAR INSTALLATION, OPERATION, OR MAINTENANCE OF THIS EQUIPMENT, THE LOCAL EATON'S ELECTRICAL SERVICES & SYSTEMS REPRESENTATIVE SHOULD BE CONTACTED.

1.1 AVAILABLE FA-VR, FB-VR, & FC-VR CIRCUIT BREAKERS

Refer to Table 1.1

Table 1. FA-VR, FB-VR, & FC-VR Availability and Interchangeability

Breaker Type	Nominal Voltage Class (kV)	Existing Breaker MVA Rating	Existing Breaker Rated Continuous Current at 60 Hz (Amps)	MVA Designation of VR-Series Breaker	Rated Voltage Factor K	Rated Withstand ANSI Test Voltage		Rated Short-Circuit kA RMS at Rated Max kV	Closing and Latching / Momentary Capabilities kA RMS/Peak
						Low Freq. kV RMS	Impulse kV Crest		
FA-VR	4.16	350	3000	350	1.19	19	60	41	78 / 132
FB-VR	7.2	500	1200 / 2000	500	1.25	36	95	33	66 / 111
FC-VR	13.8	500	1200 / 2000 / 3000	500	1.3	36	95	18	37 / 62
	13.8	500	1200 / 2000 / 3000	500U	1.3	36	95	28	58 / 97
	13.8	500	1200 / 2000 / 3000	500XU	1.3	36	95	37	77 / 130
	13.8	750	1200 / 2000 / 3000	750	1.3	36	95	28	58 / 97
	13.8	750	1200 / 2000 / 3000	750U	1.3	36	95	37	77 / 130
	13.8	1000	1200 / 2000 / 3000	1000	1.3	36	95	37	77 / 130
FC-VRG	15	N/A	1200 / 2000 / 3000	500XU	1.0	36	95	50	80 / 137

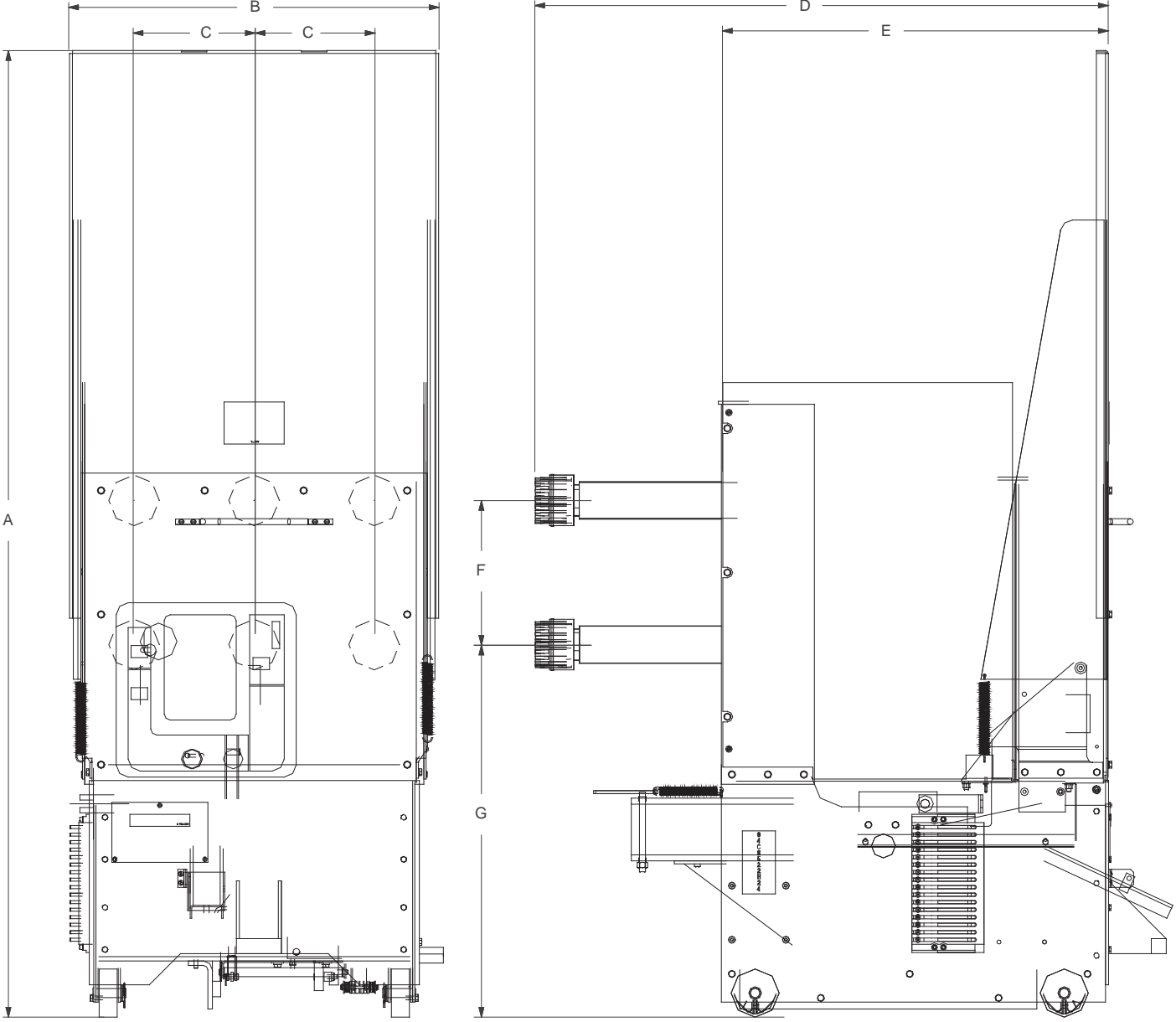


Table 2. F-Series VR Dimensions

Breaker Type	Existing Breaker Rated Continuous Current at 60 Hz (Amps)	A	B	C	D	E	F	G
FC-VR (All Ratings)	1200 / 2000	80.44	30.75	10.00	47.74	32.24	12.00	31.00

SECTION 2: SAFE PRACTICES

VR-Series breakers are equipped with high speed, high energy operating mechanisms. They are designed with several built-in interlocks and safety features to provide safe and proper operating sequences.

WARNING

TO PROTECT THE PERSONNEL ASSOCIATED WITH INSTALLATION, OPERATION, AND MAINTENANCE OF THESE BREAKERS, THE FOLLOWING PRACTICES MUST BE FOLLOWED:

- **Only qualified persons, as defined in the National Electrical Safety Code, who are familiar with the installation and maintenance of medium voltage circuits and equipment, should be permitted to work on these breakers.**
- **Read these instructions carefully before attempting any installation, operation or maintenance of these breakers.**
- **Always remove the breaker from the enclosure before performing any maintenance. Failure to do so could result in electrical shock leading to death, severe personnel injury or property damage.**
- **Do not work on a breaker with the secondary test coupler engaged. Failure to disconnect the test coupler could result in an electrical shock leading to death, personnel injury or property damage.**
- **Do not work on a closed breaker or a breaker with closing springs charged. The closing spring should be discharged and the main contacts open before working on the breaker. Failure to do so could result in cutting or crushing injuries.**
- **Do not use a circuit breaker by itself as the sole means of isolating a high voltage circuit. Remove the breaker to the Disconnect position and follow all lockout and tagging rules of the National Electrical Code and any and all applicable codes, regulations and work rules.**
- **Do not leave the breaker in an intermediate position in the cell. Always have the breaker either in the Test or Connected position. Failure to do so could result in a flash over and possible death, personnel injury or property damage.**
- **Always remove the maintenance tool from the breaker after charging the closing springs.**
- **Breakers are equipped with safety interlocks. Do not defeat them. This may result in death, bodily injury or equipment damage.**

SECTION 3: RECEIVING, HANDLING, AND STORAGE

Type FA, FB, & FC VR-series circuit breakers are subjected to complete factory production tests and inspection before being packed. They are shipped in packages designed to provide maximum protection to the equipment during shipment and storage and at the same time to provide convenient handling. Accessories such as the maintenance tool, cell code plate, etc. are shipped with the breaker (Figure 3.1).

3.1 RECEIVING

Until the breaker is ready to be delivered to the switchgear site for installation, DO NOT remove it from the shipping crate. If the breaker is to be placed in storage, maximum protection can be obtained by keeping it in its crate.

Upon receipt of the equipment, inspect the crates for any signs of damage or rough handling. Open the crates carefully to avoid any damage to the contents. Use a nail puller rather than a crow bar when required.

When opening the crates, be careful that any loose items or hardware are not discarded with the packing material. Check the contents of each package against the packing list.

Examine the breaker for any signs of shipping damage such as broken, missing or loose hardware, damaged or deformed insulation and other components. File claims immediately with the carrier if damaged or loss is detected and notify the nearest Eaton's Electrical Services & Systems office.

Tools and Accessories

Maintenance Tool: This tool is used to manually charge the closing spring. One maintenance handle is provided with each vacuum unit replacement breaker. (Style# 8064A02G01)

Levering Handle: The levering handle is used to lever the breaker in and out of the cell. The original OEM handle can be used and therefore one is not supplied with the breaker.

Rotary Racking Handle: Rotary racking is possible utilizing a speed-handle, suitable extensions and a standard 13/16" socket. One rotary racking handle is provided per order. If necessary, additional racking handles may be purchased directly from Eaton. (Style# 94A3149G11) This handle is used with the rotary racking system for insertion and removal.

Secondary Connection Block Extension Cable (Original): The extension cable can be used to connect the circuit breaker to a "test cabinet" or to the switchgear cell's secondary receptacle block so that the breaker can be electrically operated while not installed in the switchgear cell. This extension cable is the same one provided with the Allis-Chalmers breaker and is therefore not included as part of the vacuum replacement breaker.

Secondary Connection Block Extension Cable (Replacement): In the event the original secondary connection block extension cable is no longer available a new designed replacement is available from Eaton (Style #94A3147G30) (Figure 3.1.c).

Figure 3.1.a. Typical Tools and Accessories



Figure 3.1.b. Rotary Racking Handle



Figure 3.1.c. Secondary Connection Block Extension Cable Replacement (Optional)



3.2 HANDLING

⚠ WARNING

DO NOT USE ANY LIFTING DEVICE AS A PLATFORM FOR PERFORMING MAINTENANCE, REPAIR OR ADJUSTMENT OF THE BREAKER OR FOR OPENING, CLOSING THE CONTACTS OR CHARGING THE SPRINGS. THE BREAKER MAY SLIP OR FALL CAUSING SEVERE PERSONAL INJURY. ALWAYS PERFORM MAINTENANCE, REPAIR AND ADJUSTMENTS ON A WORKBENCH CAPABLE OF SUPPORTING THE BREAKER TYPE.

FA-VR, FB-VR, & FC-VR breaker shipping containers are designed to be handled either by use of a rope sling and overhead lifting device or by a fork lift truck. If containers must be skidded for any distance, it is preferable to use roller conveyors or individual pipe rollers.

Once a breaker has been inspected for shipping damage, it is best to return it to its original shipping crate until it is ready to be installed in the Metal-Clad Switchgear.

When a breaker is ready for installation, a lifting harness in conjunction with an overhead lift or portable floor lift can be used to move a breaker, if this is preferable to rolling the breaker on the floor using self contained wheels. If the breaker is to be lifted, position the lifting device (lifting straps should have at least a 1600 pound capacity) over the breaker and insert the lifting harness hooks into the breaker side openings and secure. Be sure the hooks are firmly attached before lifting the breaker. Stand a safe distance away from the breaker while lifting and moving.

Figure 3.2.a. Lifting FC-VR



Figure 3.2.b. Lifting FC-VR (Front Detail)

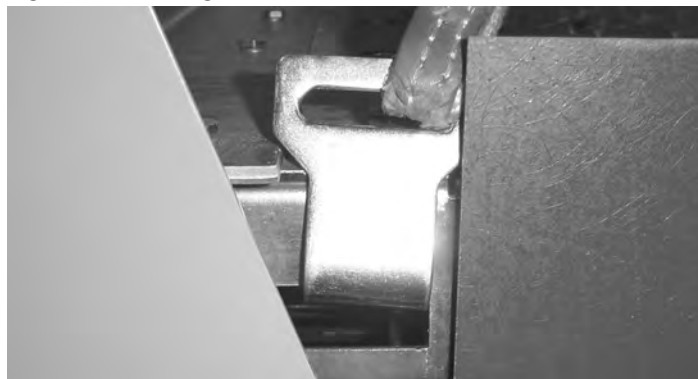
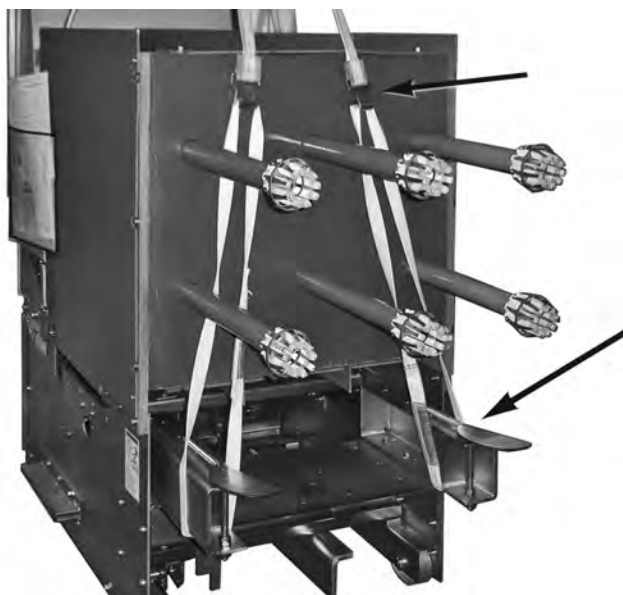


Figure 3.2.c. Lifting FC-VR (Rear Detail)



3.3 STORAGE

If the circuit breaker is to be placed in storage, maximum protection can be obtained by keeping it in the original shipping crate. Before placing it in storage, checks should be made to make sure that the breaker is free from shipping damage and is in satisfactory operating condition.

The breaker is shipped with its contacts open and closing springs discharged. The indicators on the front panel should confirm this. Insert the maintenance tool in the manual charge socket opening (Figure Set 3.3). Charge the closing springs by pumping the handle up and down about 36 times until a crisp metallic “click” is heard. This indicates that the closing springs are charged and is shown by the closing spring “charged” (yellow) indicator. Remove the maintenance tool. Push the “manual close” button. The breaker will close as shown by the breaker contacts “closed” (red) indicator. Push the “manual trip” button. The breaker will trip as shown by the breaker contacts “open” (green) indicator. After completing this initial check, leave the closing springs “discharged” and breaker contacts “open”.

Outdoor storage is NOT recommended. If unavoidable, the outdoor location must be well drained and a temporary shelter from sun, rain, snow, corrosive fumes, dust, dirt, falling objects, excessive moisture, etc. must be provided. Containers should be arranged to permit free circulation of air on all sides and temporary heaters should be used to minimize condensation. Moisture can cause rusting of metal parts and deterioration of high voltage insulation. A heat level of approximately 400 watts for each 100 cubic feet of volume is recommended with the heaters distributed uniformly throughout the structure near the floor.

Indoor storage should be in a building with sufficient heat and circulation to prevent condensation. If the building is not heated, the same general rule for heat as for outdoor storage should be applied.

3.4 FA-VR, FB-VR, & FC-VR APPROXIMATE WEIGHTS

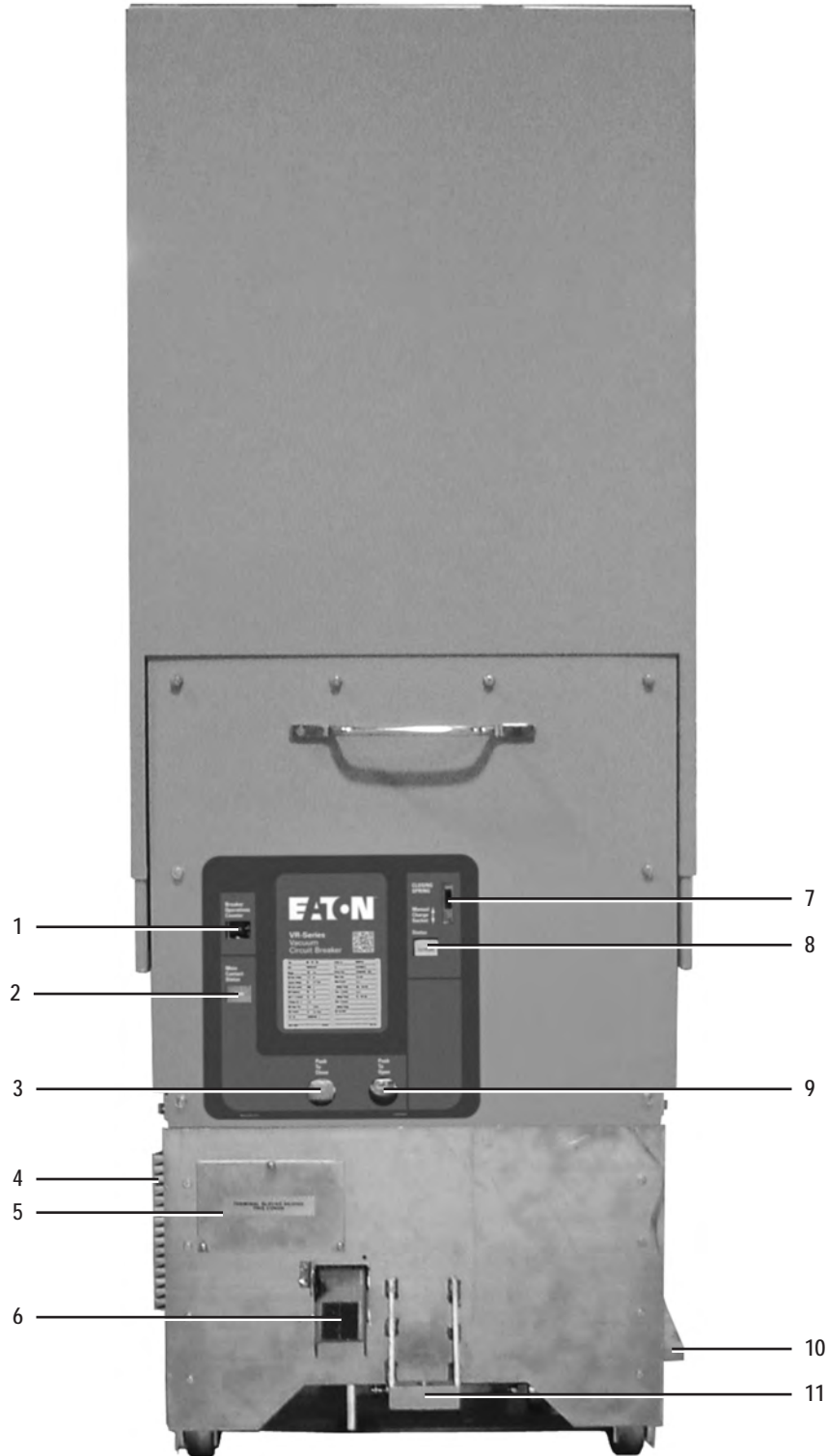
Table 3. Maximum Nominal Weight by Type

Type	Amperes	LBs
FA-VR, FB-VR, & FC-VR	1200	950*
	2000	1100*
	3000	1250*

Note: * = An additional 75lbs is added with the optional internal Rotary Racking system.

FA-VR, FB-VR, & FC-VR
Replacement Circuit Breaker

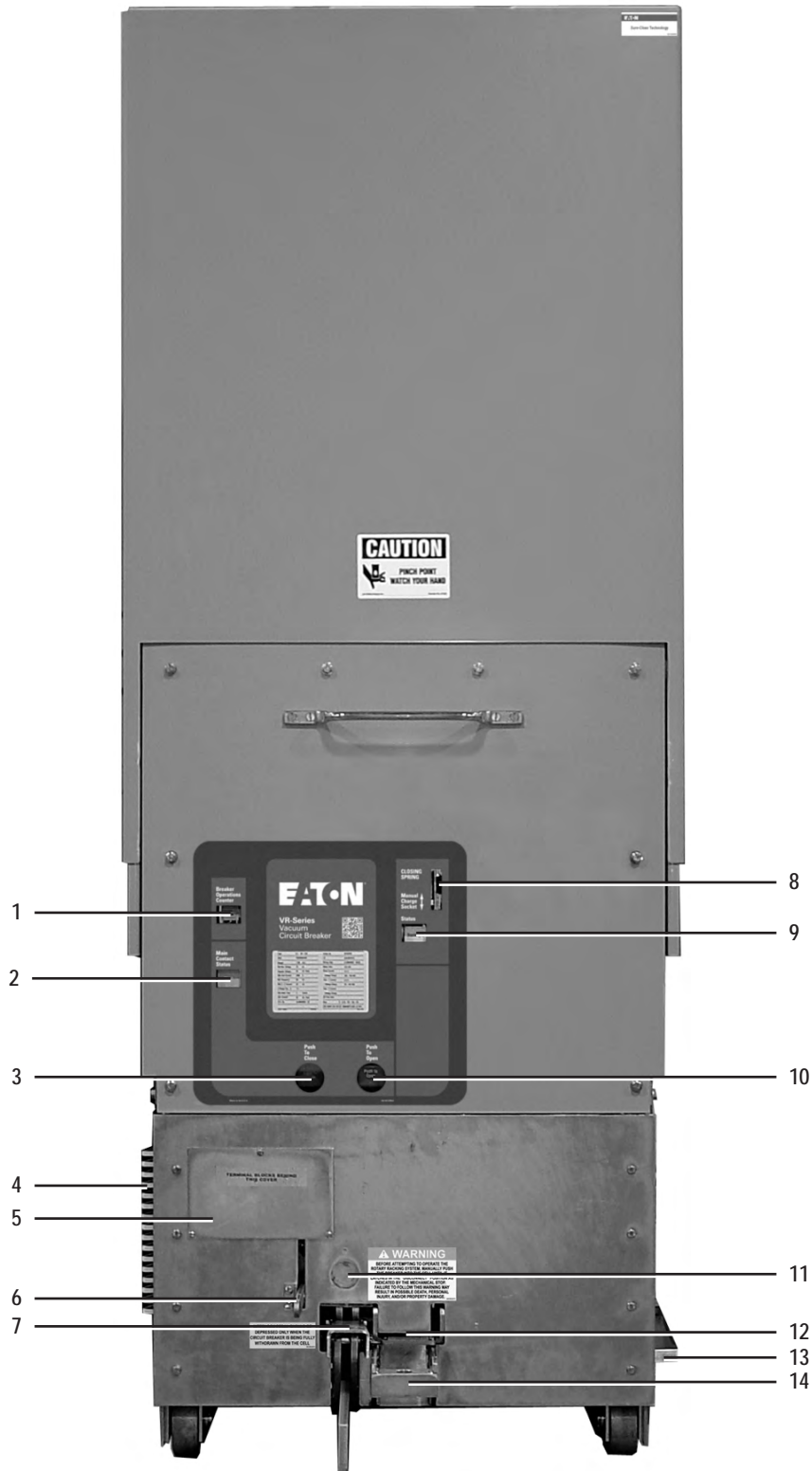
Figure 3.3.a Front External View of FC-VR (Standard Levering Design)



Front External View

1	Operations Counter	5	Terminal Block Cover	9	Push To Open Button
2	Breaker Contacts Indicator	6	Interlock Pedal	10	Shutter Actuator
3	Push To Close Button	7	Manual Charging Socket	11	Tow Hitch
4	Secondary Disconnect	8	Spring Charged / Discharged Indicator		

Figure 3.3.b Front External View of FC-VR (Internal Rotary Racking Design)

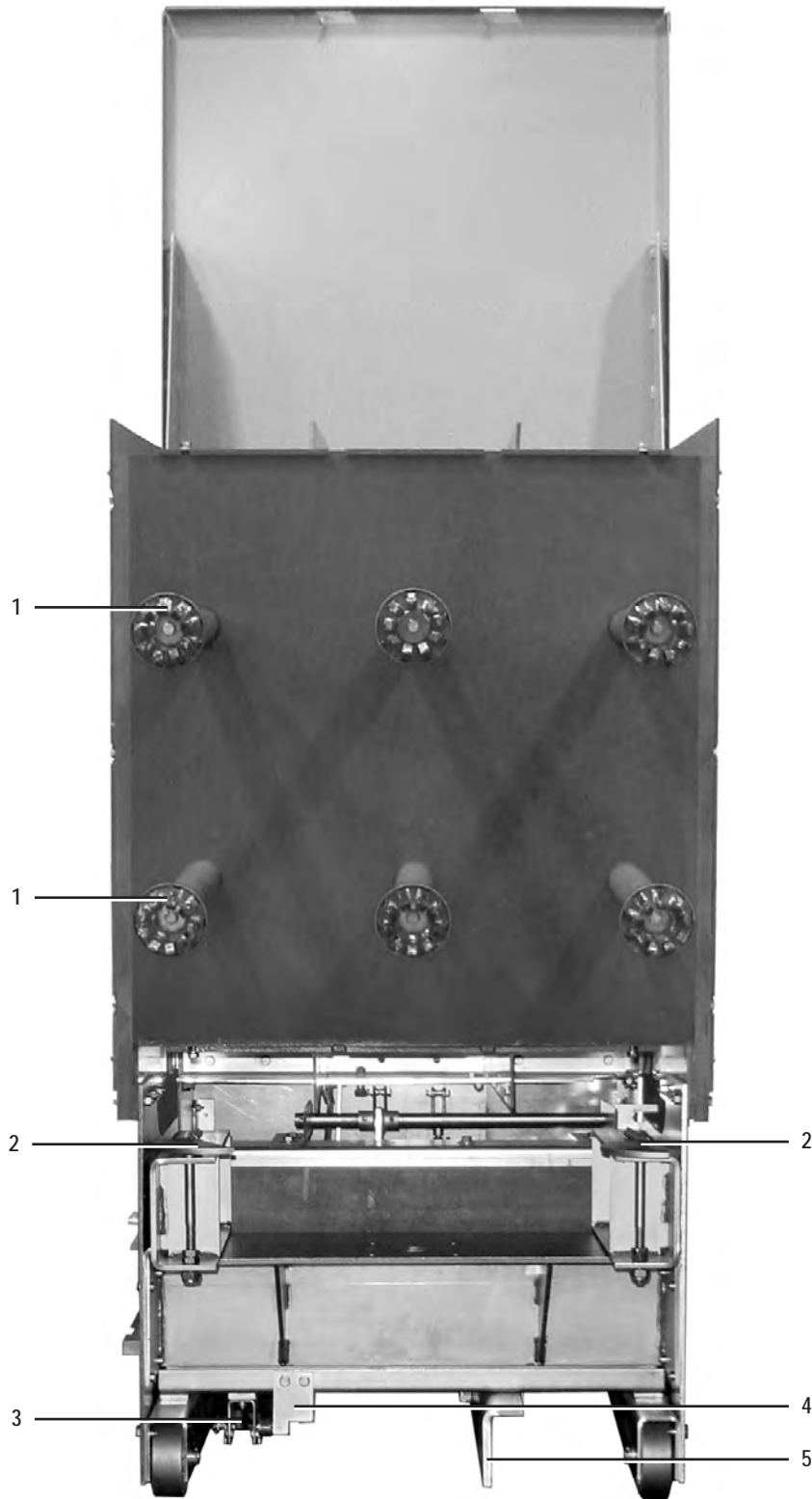


Front External View

1	Operations Counter	6	Racking Access Handle	11	Rotary Racking Access
2	Breaker Contacts Indicator	7	Interlock Pedal	12	Breaker Position Indicator
3	Push To Close Button	8	Manual Charging Socket	13	Shutter Actuator
4	Secondary Disconnect	9	Spring Charged / Discharged Indicator	14	Tow Hitch
5	Terminal Block Cover	10	Push To Open Button		

FA-VR, FB-VR, & FC-VR
Replacement Circuit Breaker

Figure 3.3.c Rear External View of FC-VR



Rear External View

1 Primary Disconnect	3 Ground Contact	5 Guide Rail
2 Anti-Rotation Hold Downs	4 Code Plate	

SECTION 4: DESCRIPTION AND OPERATION

VR-Series vacuum replacement breakers are designed to be used with existing installations of equivalent air-magnetic metal-clad switchgear breaker. The front mounted spring type stored energy mechanism facilitates inspection and provides improved access to components for servicing. The long life characteristics of the vacuum interrupters and proven high reliability of spring-type stored energy mechanisms assure long, trouble-free service with minimum maintenance.

4.1 VACUUM INTERRUPTER

Vacuum interrupters offer the advantages of enclosed arc interruption, small size and weight, longer life, reduced maintenance, minimal mechanical shock, and elimination of contact degradation caused by environmental contamination.

In the closed position, current flows through the interrupter moving and fixed stems and the faces of the main contacts. As the contacts part, an arc is drawn between the contact surfaces. The arc is rapidly moved away from the main contacts to the slotted contact surfaces by self-induced magnetic effects. This minimizes contact erosion and hot spots on the contact surfaces. The arc flows in an ionized metal vapor and as the vapor leaves the contact area, it condenses into the metal shield which surrounds the contacts.

At current zero, the arc extinguishes and vapor production ceases. Very rapid dispersion, cooling, recombination, and deionization of the metal vapor plasma and fast condensation of metal vapor causes the vacuum to be quickly restored and prevents the transient recovery voltage from causing a restrike across the gap of the open contacts.

4.1.1 THE INTERRUPTER ASSEMBLY

Each interrupter is assembled at the factory as a unit to assure correct dimensional relationships between working components. The interrupter assembly consists of a vacuum interrupter, a molded glass polyester stand-off insulator, upper and lower clamps, flexible shunts, bell crank, operating rod, and contact load spring. The vacuum interrupter is mounted vertically with the fixed stem upward and the moving stem downward. The upper and lower glass polyester stand-off insulator and clamps support the interrupter and are fastened to the breaker's stored energy mechanism frame. Upper and lower flexible shunts provide electrical connections from each interrupter to the breaker's primary bushings while providing isolation from mechanical shock and movement of the interrupter's moving stem. The operating rod, loading spring, and bell crank transfer mechanical motion from the breaker's operating mechanism to the moving stem of the interrupter. A vacuum interrupter contact erosion indicator is located on the moving stem of the interrupter. It is visible when the breaker is withdrawn and is viewed from the rear of the breaker. (See Figure 6.1 and Figure 6.2)

4.1.2 CONTACT EROSION INDICATOR

The purpose of the contact erosion indicator is to monitor the erosion of the vacuum interrupter contacts, which is very minimal over time with Eaton vacuum interrupters utilizing copperchrome contact material. A contact erosion indicator mark is located on the moving stem of the interrupter (Figure 6.1 and 6.2).

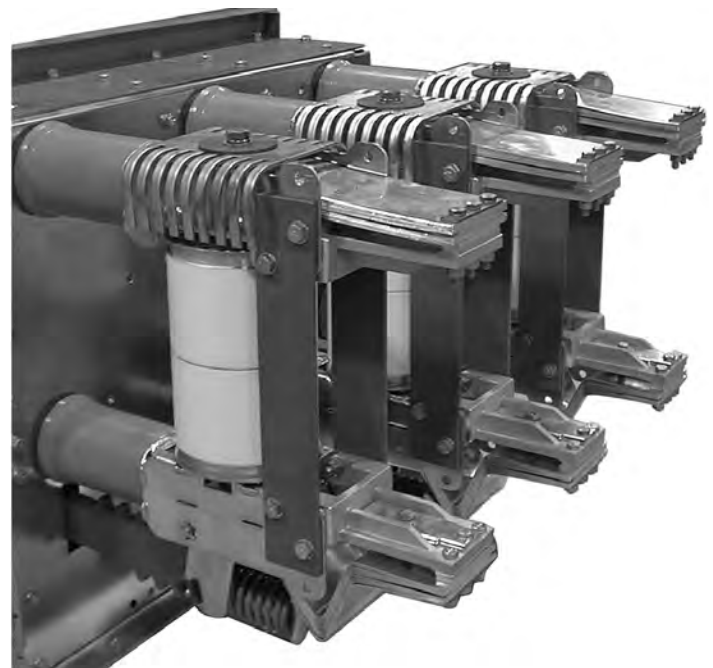
In order to determine if the contacts have eroded to the extent that the interrupter must be replaced, close the breaker and observe the erosion mark placed on each moving stem from the rear of the breaker. If the mark on the interrupter stem is visible, the interrupter is satisfactory. If the mark is no longer visible, the interrupter assembly must be replaced.

The erosion indicator is easily viewed from the rear on the 7.5 or 15kV designs. Because of the nature of the 5kV 20-WR element inverted design, the erosion indicator is not easily viewed, although it is possible with the use of a light and an inspection type mirror.

Figure 4.1. 29WR Interrupter Assembly



Figure 4.2. 29WR Interrupter Assembly (All Three Pole Units)
(Note: 18WR, 20WR, and 50G Interrupters Similar)



⚠ WARNING

FAILURE TO REPLACE THE INTERRUPTER ASSEMBLY WHEN INDICATED BY THE CONTACT EROSION INDICATOR COULD CAUSE THE BREAKER TO FAIL, LEADING TO DEATH, PERSONAL INJURY OR PROPERTY DAMAGE.

4.1.3 CONTACT WIPE AND STROKE

Contact wipe is the indication of (1) the force holding the vacuum interrupter contacts closed and (2) the energy available to hammer the contacts open with sufficient speed for interruption.

Stroke is the gap between fixed and moving contacts of a vacuum interrupter with the breaker open.

The circuit breaker mechanism provides a fixed amount of motion to the operating rods. The first portion of the motion is used to close the contacts (i.e. stroke) and the remainder is used to further compress the preloaded wipe spring. This additional compression is called wipe. Wipe and stroke are thus related to each other. As the stroke increases due to the erosion of contacts, the wipe decreases. A great deal of effort and ingenuity has been spent in the design of VR-Series breakers, in order to eliminate any need for field adjustment of wipe or stroke.

⚠ WARNING

THERE IS NO PROVISION FOR IN-SERVICE ADJUSTMENTS OF CONTACT WIPE AND STROKE. ALL SUCH ADJUSTMENTS ARE FACTORY SET AND SHOULD NOT BE ATTEMPTED IN THE FIELD.

4.2 PHASE BARRIERS

Phase barriers are sheets of insulation located between the interrupter pole assemblies and on the sides of the breaker frame. The phase barriers are designed to isolate energized conductor components in each phase from the adjacent phase and ground.

⚠ WARNING

ALL PHASE BARRIERS MUST BE IN PLACE BEFORE PLACING THE CIRCUIT BREAKER INTO SERVICE. FAILURE TO HAVE THEM IN POSITION CAN CAUSE DEATH, SERIOUS PERSONNEL INJURY AND/OR PROPERTY DAMAGE.

4.3 BUSHINGS AND DISCONNECTING CONTACT ASSEMBLIES

The line and load bushing assemblies, which are the primary circuit terminals of the circuit breaker, consist of six silver plated conductors. Multiple finger type primary disconnecting contacts at the ends of the conductors provide means for connecting and disconnecting the breaker to the bus terminals in the switchgear compartment.

4.4 STORED ENERGY MECHANISM

The spring-type stored energy operating mechanism is mounted on the breaker frame and in the front of the breaker. Manual closing and opening controls are at the front panel (Figure Set 3.3). They are accessible while the breaker is in any of its four basic positions. (See Section 5 in this manual)

The mechanism stores the closing energy by charging the closing springs. When released, the stored energy closes the breaker, charges the wipe and resets the opening springs. The mechanism may rest in any one of the four positions shown in Figure 4.8 as follows:

- Breaker open, closing springs discharged.
- Breaker open, closing springs charged.
- Breaker closed, closing springs discharged.
- Breaker closed, closing springs charged.

The mechanism is a mechanically “trip-free” design. Trip-free is defined later in this section.

In normal operation the closing spring is charged by the spring charging motor, and the breaker is closed electrically by the switchgear control circuit signal to energize the spring release coil. Tripping is caused by energizing the trip coil through the control circuit.

For maintenance inspection purposes the closing springs can be charged manually by using the maintenance tool and the breaker can be closed and tripped by pushing the “Push to Close” and “Push to Open” buttons on the front panel.

⚠ WARNING

KEEP HANDS AND FINGERS AWAY FROM BREAKER'S INTERNAL PARTS WHILE THE BREAKER CONTACTS ARE CLOSED OR THE CLOSING SPRINGS ARE CHARGED. THE BREAKER CONTACTS MAY OPEN OR THE CLOSING SPRINGS DISCHARGE CAUSING CRUSHING INJURY. DISCHARGE THE SPRINGS AND OPEN THE BREAKER BEFORE PERFORMING ANY MAINTENANCE, INSPECTION OR REPAIR ON THE BREAKER.

THE DESIGN OF THIS CIRCUIT BREAKER ALLOWS MECHANICAL CLOSING AND TRIPPING OF THE BREAKER WHILE IT IS IN THE “CONNECT” POSITION. HOWEVER, THE BREAKER SHOULD BE CLOSED MECHANICALLY ONLY IF THERE IS POSITIVE VERIFICATION THAT LOAD SIDE CONDITIONS PERMIT. IT IS RECOMMENDED THAT CLOSING THE BREAKER IN THE “CONNECT” POSITION ALWAYS BE DONE WITH THE CUBICLE DOOR CLOSED. FAILURE TO FOLLOW THESE DIRECTIONS MAY CAUSE DEATH, PERSONAL INJURY, OR PROPERTY DAMAGE.

ELECTRICAL TRIPPING CAN BE VERIFIED WHEN THE BREAKER IS IN THE “TEST” POSITION.

4.4.1 CLOSING SPRING CHARGING

Figure 4.7 shows schematic section views of the spring charging parts of the stored energy mechanism.

The major component of the mechanism is a cam shaft assembly which consists of a shaft to which are attached two closing spring cranks (one on each end), the closing cam, drive plate, and a free-wheeling ratchet wheel.

The ratchet wheel (6) is actuated by an oscillating ratchet lever (12) and drive pawl (10) driven by the motor eccentric cam. As the ratchet wheel rotates, it pushes the drive plates which in turn rotate the closing spring cranks and the closing cam on the cam shaft. The motor will continue to run until the limit switch “LS” contact disconnects the motor.

The closing spring cranks have spring ends connected to them, which are in turn coupled to the closing springs. As the cranks rotate, the closing springs get charged.

The closing springs are completely charged, when the spring cranks go over dead center and the closing stop roller (9) comes against the spring release latch (1). The closing springs are now held in the fully charged position.

The closing springs may also be charged manually as follows: Insert the maintenance tool in the manual charging socket. Move it up and down several times (about 36) until a clicking sound is heard and closing spring status indicator shows “charged” (Figure Set 3.3). Any further motion of the maintenance tool will result in free wheeling of the ratchet wheel and will not result into advance of charging.

4.4.2 CLOSING OPERATION

Figure 4.8 shows the positions of the closing cam and tripping linkage for four different operational states. In Figure 4.8.a the breaker is open and the closing springs are discharged. In this state, the trip latch is disengaged from the trip “D” shaft (unlatched). After the closing springs become charged, the trip latch snaps into the fully reset or latched position (Figure 4.8.b)

When the spring release clapper (Figure 4.7, Item 13) moves into the face of the spring release coil (electrically or manually), the upper portion of the clapper pushes the spring release latch (1) upward. When the spring release latch moves, the cam shaft assembly is free to rotate. The force of the closing cam (Figure 4.8.b, Item 5), moving the main link (2), rotating the pole shaft (4) (which charges the opening spring). This moves the three operating rods (3), closes the main contacts and charges the contact loading springs (not shown). The operational state immediately after the main contacts close but before the spring charging motor recharges the closing springs is illustrated in Figure 4.8.c. Interference of the trip “D” shaft with the trip latch prevents the linkage from collapsing, and holds the breaker closed.

Figure 4.8.d shows the breaker in the closed state after the closing springs have been recharged. The recharging of the spring rotates the closing cam one half turn. In this position the main link roller rides on the cylindrical portion of the cam, and the main link does not move out of position.

4.4.3 TRIPPING OPERATION

When the trip bar “D” shaft (Figure 4.8.b, Item 9) is turned by movement of the shunt trip clapper (11), the trip latch will slip past the straight cut portion of the trip bar shaft and will allow the banana link and main link roller to rise. The energy of the opening spring and contact loading springs is released to open the main contacts. The mechanism is in the state illustrated (Figure 4.8.b) after the breaker is tripped open.

4.4.4 TRIP-FREE OPERATION

When the manual trip button is held depressed, any attempt to close the breaker results in the closing springs discharging without any movement of the pole shaft or vacuum interrupter stem.

4.5 CONTROL SCHEMES

There are two basic control schemes for each series of Type VCP-VR breakers, one for DC control and one for AC control voltages (Figure 4.3). Specific wiring schematics and diagrams are included with each breaker.

There may be different control voltages or more than one tripping element, but the principal mode of operation is as follows:

As soon as the control power is applied, the spring charging motor automatically starts charging the closing spring. When the springs are charged, the motor cut off LS1/bb switch turns the motor off. The breaker may be closed by making the control switch close (CS/C) contact. Automatically upon closing of the breaker, the motor starts charging the closing springs. The breaker may be tripped any time by making the control switch (CS/T) contacts.

Note the position switch (PS1) contact in the spring release circuit in the scheme. This contact remains made while the breaker is being racked between the TEST and CONNECTED positions for appropriately retrofitted breakers. Consequently, it prevents the breaker from closing automatically, even though the control close contact may have been made while the breaker is racked to the CONNECTED position.

When the CS/C contact is made, the SR closes the breaker. If the CS/C contact is maintained after the breaker closes, the Y relay is picked up. The Y/a contact seals in Y until CS/C is opened. The Y/b contact opens the SR circuit, so that even though the breaker would subsequently open, it could not be reclosed before CS/C was released and remade. This is the anti-pump function.

4.5.1 TIMING

The opening and closing times for the circuit breakers vary depending upon the control voltage, power rating, environment and test equipment. Differences in timing are expected between initial factory measurements and field inspections. Circuit breaker timing can be measured by service personnel using available equipment before installation and in conjunction with regular maintenance periods to assist in tracking the general health of the breaker. Typical ranges as observed using nominal control voltages are listed in Table 4.

Table 4. Time Per Event

Event	Milliseconds / Maximum
Closing Time (From Initiation of Close Signal to Contact Make)	75
Opening Time (Initiation of Trip Signal to Contact Break)	45
Reclosing Time (Initiation of Trip Signal to Contact Make)	190

4.6 SECONDARY CONNECTION BLOCK

The breaker control circuit is connected to the switchgear control through secondary connection block, located at the lower left rear of the breaker. The contacts engage automatically when the breaker is racked into the “test” and “connect” positions. The socket half of the connection is located in the cubicle and a jumper of multiconductor cable can complete the control connections (for testing) when the breaker is withdrawn from the cell.

4.7 INTERLOCKS

⚠ WARNING

INTERLOCKS ARE PROTECTIVE DEVICES FOR PERSONNEL AND EQUIPMENT. DO NOT BYPASS, MODIFY, OR MAKE INOPERATIVE ANY INTERLOCKS. DOING SO COULD CAUSE DEATH, SERIOUS PERSONAL INJURY, AND/OR PROPERTY DAMAGE.

There are several interlocks built into the VR-Series vacuum replacement breakers. Each of these interlocks, though different in form, duplicate or exceed in function that of the original breaker. These interlocks exist to safeguard personnel and equipment. The basic premise behind the interlocking arrangement on the vacuum replacement breaker is that the breaker must not be inserted into or removed from a live circuit while the main contacts are closed. Also considered in the interlocking is that the breaker should pose no greater risk than necessary to the operator in or out of the cell. In addition to the original interlocks, VR-Series breakers provide an anti-close interlock.

4.7.1 ANTI-CLOSE INTERLOCK

The anti-close interlock prevents discharging of the closing springs if the breaker is already closed (Figure 4.7, Item 11). When the breaker is closed, the interlock component moves away from the spring release clapper so that it cannot lift the spring release latch (9).

4.7.2 INTERLOCK PEDAL (AND PLUNGER)

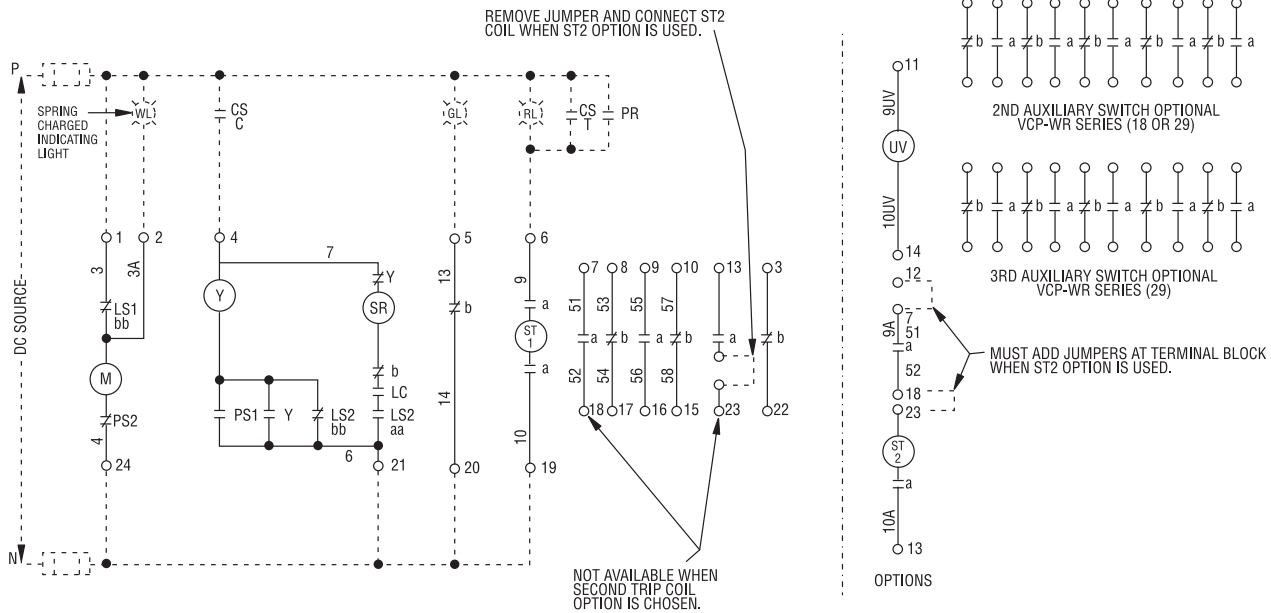
The interlock pedal and associated plunger prevents engaging a shut breaker with live cell bus work or removing a potentially hazardous breaker from the cell. The interlock pedal operates the interlock plunger as well as the trip mechanism. Lifting the handle trips the breaker and raises the plunger sufficiently to release the breaker allowing it to be moved in the cubicle. The interlock is in proper adjustment when the plunger is positioned to 1-11/16” to 1-13/16” above the floor line, and causes tripping of the breaker when it is raised to a level of not more than 2-1/16” above the floor line.

4.7.3 INTERNAL ROTARY RACKING

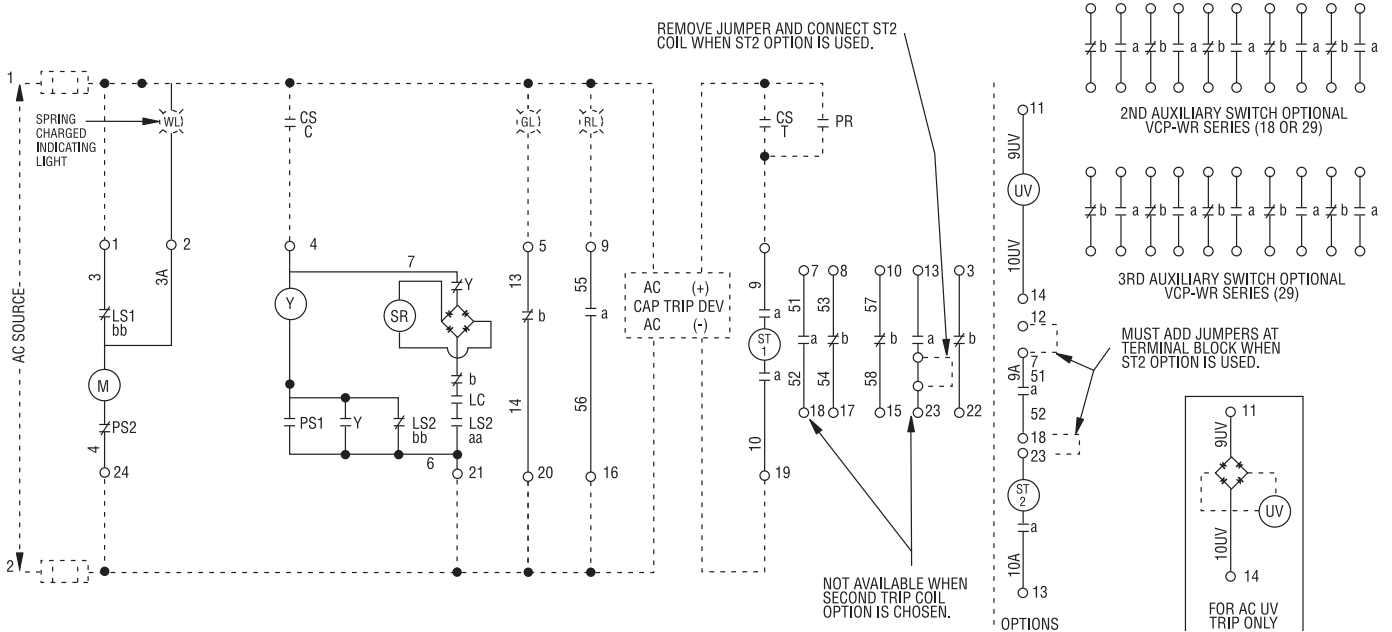
An active interlock is provided to keep the breaker in a trip free position when the breaker is between the test and fully connected position; no adjustments are necessary. In addition to the active interlock, two passive interlocks are provided; one to prevent engaging the rotary racking handle into the breaker when the breaker is closed, and one to prevent turning the rotary shaft in the breaker when the breaker is closed.

Figure 4.3. Typical ac/dc Schematic

VR-Series Circuit Breaker dc Control Schematic



VR-Series Circuit Breaker ac Control Schematic



OPERATION

CS - Breaker Control Switch - close

CS - Breaker Control Switch - trip

Y - Anti Pump Relay

SR - Spring Release Coil (Close Coil)

M - Spring Charging Motor

ST - Shunt Trip Coil

PR - Protective Relay

O - Terminal Block or Accessible Terminal

PS1 - Position Switch 1

PS2 - Position Switch 2

LS1 bb - Closed until springs are fully charged

LS2 aa - Open until springs are fully charged

LS2 bb - Closed until springs are fully charged

LC - Open until mechanism is reset

PS1 - Open in all except between 'Test' and 'Connect' positions

PS2 - Closed in all except between 'Test' and 'Connect' positions

SWITCH TERMINAL

'C' and 'NO' - Brown Switch

'C' and 'NC' - Black Switch

'C' and 'NO' - Black Switch

'C' and 'NC' - Black Switch

'C' and 'NO' - Brown Switch

4.7.4 PASSIVE INTERLOCK (If Equipped)

When the breaker is in the withdrawn, test, or connected position, and the breaker is closed, the passive interlock prevents moving unless the breaker is transitioned to the open position.

⚠ WARNING

EXCESSIVE FORCE ON THE PASSIVE INTERLOCK WHILE THE BREAKER IS CLOSED COULD CAUSE DAMAGE TO THE INTERLOCK SYSTEM AND RESULT IN FAILURE OF THE PASSIVE INTERLOCK FEATURE.

If the passive interlock is damaged and fails, the breaker will be tripped by an active interlock preventing a closed breaker from being removed from the cell.

4.7.5 SHUTTER OPERATING MECHANISM

The grounded aluminum shutters automatically close the opening to the cubicle primary disconnects when the circuit breaker is withdrawn from its connect position. The protective shutters guard against accidental human contact with the cubicle primary disconnect members. They also keep foreign matter from entering the disconnect chambers. Shutters are designed to remain closed until the movable primary disconnects on the breaker are in position to enter the cubicle disconnect chambers.

The two shutter blades operate with a counterbalanced action. One blade moves up while the other moves down. This design requires a minimum of operating forces with smooth shutter operation. Blades are actuated through a common link bar and shutter roller by a guide on the right side of the circuit breaker frame.

4.8 RACKING SYSTEM TRIP AND SPRING RELEASE INTERLOCKS

The racking system tripping and spring release interlocks perform the following:

- Set the breaker mechanically trip-free during the first 4 inches of travel into the cell and whenever the breaker receives a close signal in an intermediate or the disconnect position.
- Set the breaker in a safe condition (breaker open, springs discharged) when removed from the cell.
- Insert a mechanical trip signal to open a position switch preventing energizing of the spring release coil whenever the breaker is in an intermediate position.
- Prevent inadvertent cycling (pumping) of the breaker between the test and connect positions.
- Prevent insertion of a closed breaker into the cell.

4.9 MOC (Mechanically Operated Contacts) OPERATOR

The MOC operator located on the breaker frame is linked to the breaker main pole shaft. When the breaker closes, regardless of whether it is in the cubicle, the MOC linkage of the breaker will cause the exterior MOC operator to rapidly rise. Care should be exercised to avoid contact with this mechanism. Inside the cubicle, there is a lever system connected to a MOC switch. If the breaker is in the "test" (on some designs) or "connected" position the MOC operator will operate the MOC switch when the breaker closes. The MOC switch contains contacts which are used to interlock the circuit breaker with other external devices and can provide breaker status indication.

⚠ WARNING

EXTREME CARE SHOULD BE TAKEN TO AVOID PERSONNEL OR EQUIPMENT CONTACT WITH THE MOC SYSTEM WHEN OPERATING THE BREAKER DUE TO THE ASSOCIATED MECHANICAL FORCE. CONTACT WITH THE MOC OPERATOR DURING OPERATION COULD RESULT IN INJURY.

Figure 4.4. Cell TOC Switch



4.10 TOC (Truck Operated Contacts) OPERATOR

The TOC switch, normally located on the right rear side of the cubicle, is operated by the breaker truck frame. If the breaker is fully racked into the cell, the truck frame operates the paddle of the TOC switch. The TOC switch contains contacts which are used to interlock the circuit breaker with other external devices and provide remote indication of breaker position (Figure 4.4). Adjust TOC switch as necessary for proper operation prior to inserting any replacement breaker.

4.11 RACKING MECHANISM

4.11.1 INTERNAL ROTARY RACKING

The internal rotary racking system is a safety improvement to the original method of levering (inserting and removing) medium voltage breakers. Each breaker, when properly equipped, can be racked from "DISCONNECT" to "TEST" and then to "CONNECT" using a racking crank to rotate an onboard screw driven mechanism. For the specifics of the racking process, see Section 4.5 of this instruction book. The rotary racking system also interfaces with Eaton's RPR-2 Remote Power Racking system to allow the operator to be 25 feet or more away from the door during the process of insertion or removal.

4.11.2 LEVERING HANDLE RACKING

Earlier revisions of the FA-VR, FB-VR, & FC-VR supported the original method of levering racking system. Information about this racking system can be found in Appendix A of this booklet.

⚠ WARNING

DO NOT FORCE THE BREAKER INTO THE CELL. DOING SO MAY DAMAGE PARTS THEREBY RISKING DEATH, PERSONAL INJURY, AND/OR PROPERTY DAMAGE.

4.12 GROUNDING CONTACT

The grounding contact is an assembly of spring loaded fingers which ground the breaker frame (static ground) by engaging the switchgear cell grounding bus when the breaker is racked into the cell. The ground contact is located at the rear of the breaker near the floor and visible from the back of the breaker when out of the cell.

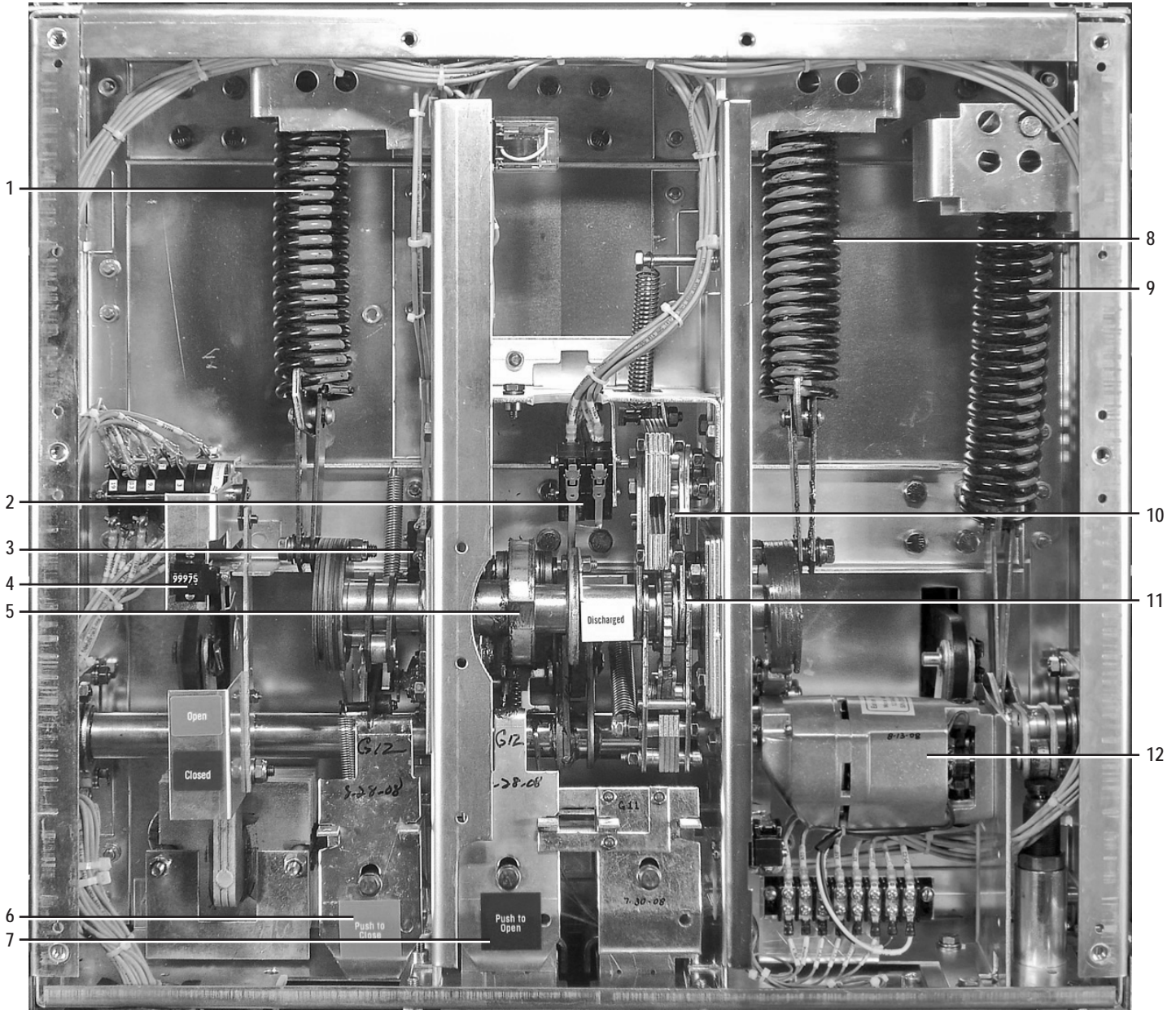
4.13 MISCELLANEOUS ITEMS

4.13.1 OPERATIONS COUNTER

All FA-VR, FB-VR, & FC-VR breakers are equipped with a mechanical operations counter (Figures 3.3). As the breaker opens, the linkage connected to the pole shaft lever advances the counter reading by one.

FA-VR, FB-VR, & FC-VR
Replacement Circuit Breaker

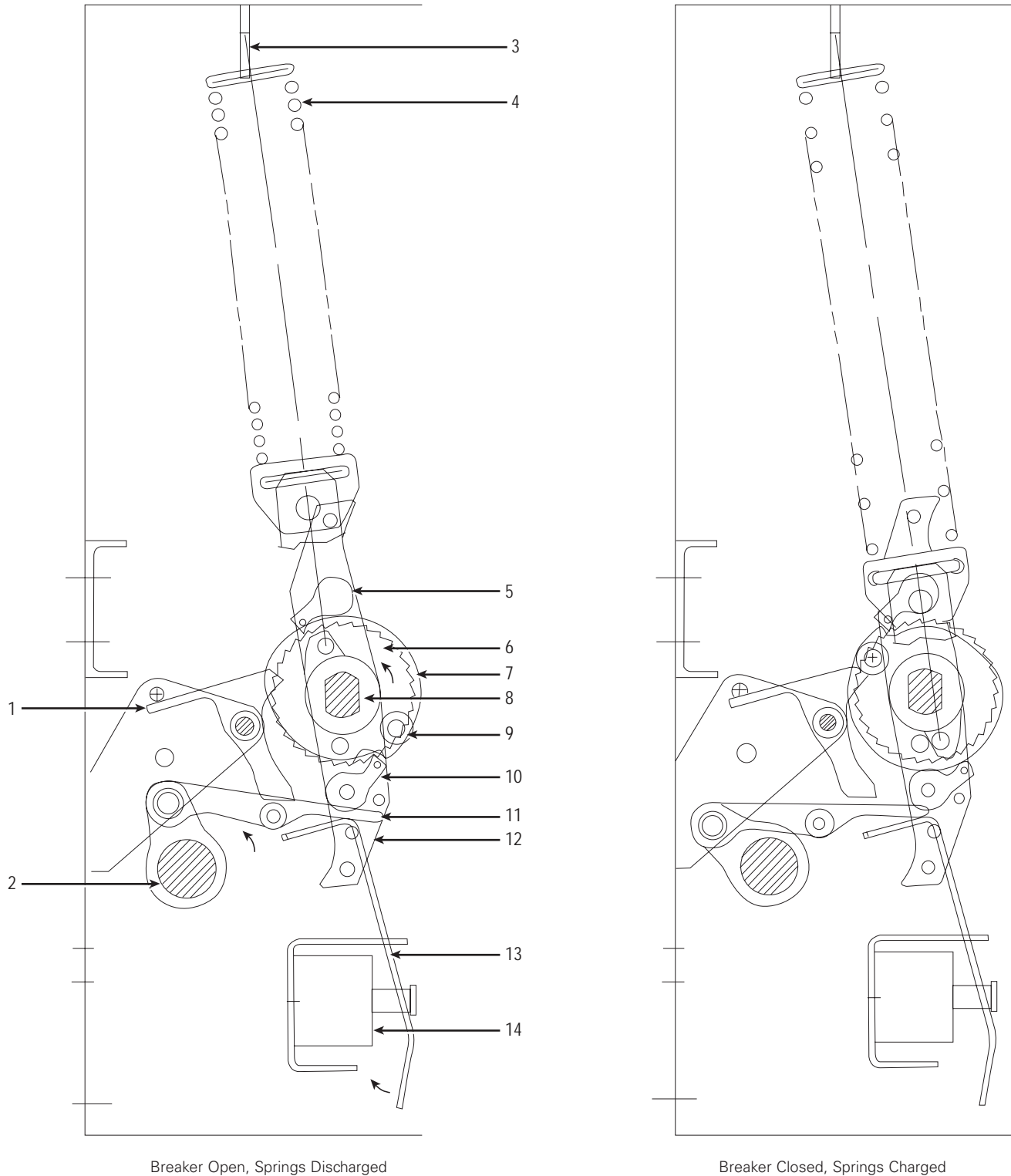
Figure 4.6. 29WR Vacuum Element - Front Faceplate Removed



29WR Vacuum Element

1	LH Closing Spring	5	Closing Cam	9	Reset Opening Spring
2	Motor Cutoff Switch	6	Spring Release Assembly	10	Manual Charge Socket
3	Latch Check Switch (Rear)	7	Shunt Trip Assembly	11	Ratchet wheel
4	Operations Counter	8	RH Closing Spring	12	Charging Motor

Figure 4.7. Closing Cam and Trip Linkage

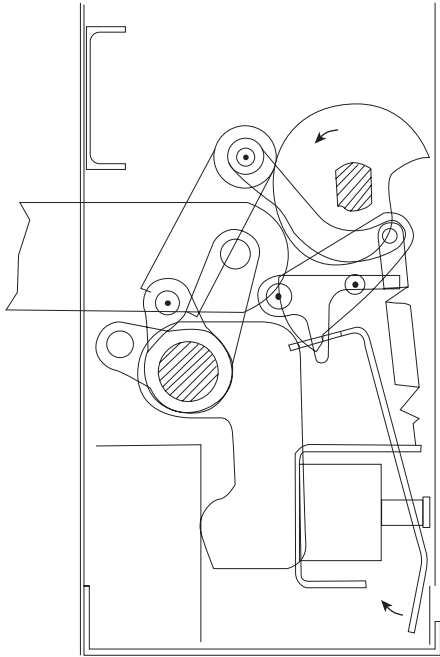


Closing Cam and Trip Linkage

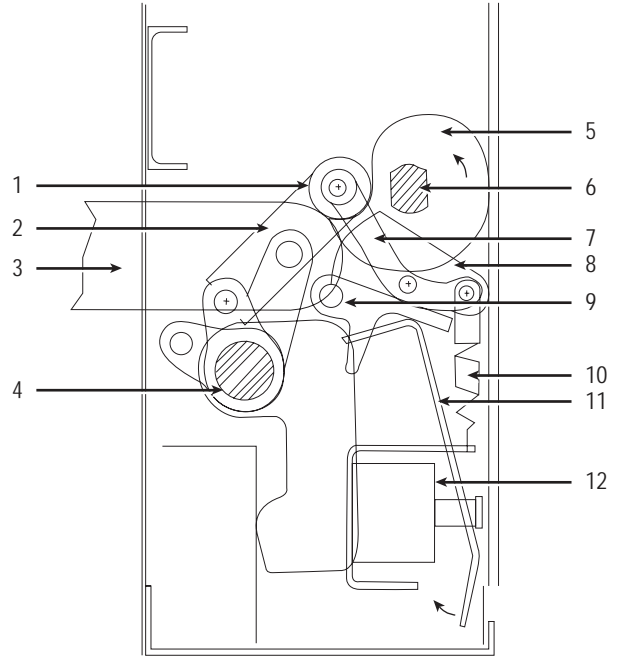
1	Spring Release (Close) Latch	6	Ratchet Wheel	11	Anti-Close Interlock
2	Pole Shaft	7	Spring Crank	12	Motor Ratchet Lever
3	Closing Spring Fixed End	8	Cam Shaft	13	Spring Release (Close) Clapper
4	Closing Spring	9	Spring Release Latch (Close Roller)	14	Spring Release (Close) Coil
5	Holding Pawl	10	Drive Pawl		

FA-VR, FB-VR, & FC-VR Replacement Circuit Breaker

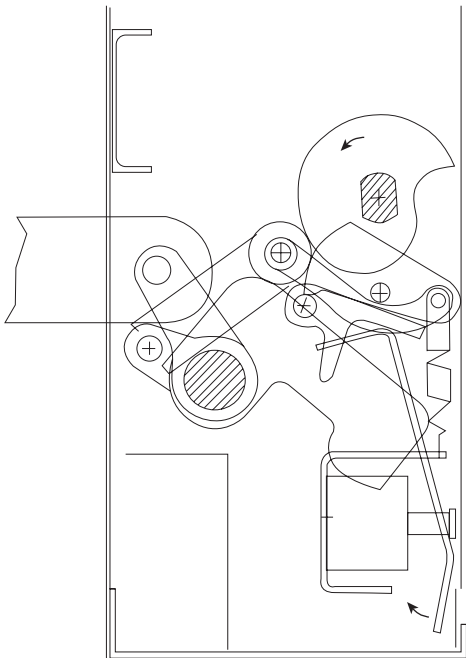
Figure 4.8. Charging Schematic



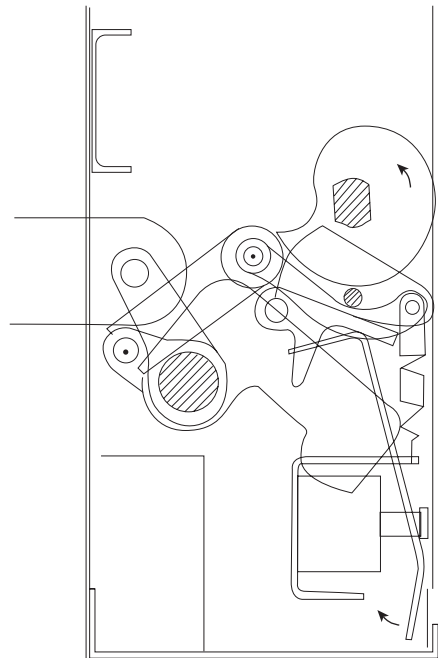
4.8.a. Breaker Open and Closing Spring Not Charged



4.8.b. Breaker Open and Closing Spring Charged



4.8.c. Breaker Closed and Closing Spring Not Charged



4.8.d. Breaker Closed and Closing Spring Charged

Charging Schematic

1	Main Link Roller	5	Closing Cam	9	Trip Bar "D" Shaft
2	Main Link	6	Cam Shaft	10	Trip Latch Reset Spring
3	Operating Rod	7	Banana Link	11	Shunt Trip Lever
4	Pole Shaft	8	Trip latch	12	Shunt Trip Coil

SECTION 5: INSPECTION & INSTALLATION

⚠ WARNING

BEFORE PLACING THE BREAKER IN SERVICE, CAREFULLY FOLLOW THE INSTALLATION PROCEDURE BELOW AND THE SAFE PRACTICES SET FORTH IN SECTION 2. NOT FOLLOWING THE PROCEDURE MAY RESULT IN INCORRECT BREAKER OPERATION LEADING TO DEATH, BODILY INJURY, AND PROPERTY DAMAGE.

When the breaker is first commissioned into service and each time the breaker is returned to service, it should be carefully examined and checked to make sure it is operating correctly.

5.1 EXAMINATION FOR DAMAGE

Examine the breaker for loose or obviously damaged parts. Never attempt to install nor operate a damaged breaker.

5.1.1 NAMEPLATE VERIFICATION

Verify the information on the new VR-Series nameplate matches the information on the purchase order. If any discrepancies exist, notify Eaton's Electrical Services & Systems for resolution prior to proceeding.

⚠ WARNING

ALWAYS DE-ENERGIZE/ISOLATE THE POWER SOURCE FEEDING THE POWER CIRCUIT BREAKERS/SWITCHGEAR AND LOCK-OUT/TAG-OUT THE POWER SOURCE PRIOR TO INSERTION OR REMOVAL OF ANY POWER CIRCUIT BREAKER. NEVER ATTEMPT TO MAINTAIN OR MODIFY A CIRCUIT BREAKER WHILE INSERTED IN A SWITCHGEAR CELL STRUCTURE. ALWAYS REMOVE THE POWER CIRCUIT BREAKER AND MOVE IT TO A SUITABLE AREA FOR MAINTENANCE OR REPAIR.

FOLLOW ALL LOCKOUT AND TAG-OUT REQUIREMENTS OF THE NATIONAL ELECTRIC CODE, OSHA AND ANY OTHER APPLICABLE LOCAL CODES, REGULATIONS AND PROCEDURES.

5.2 CELL CODE / REJECTION PLATE INSTALLATION

Cell code plates and air circuit breaker rejection plates are required to reject circuit breakers that do not match the electrical ratings of the existing cell. There are two styles of cell code plates, one for standard FC-VR short circuit and momentary ratings and another for higher, generator class FC-VRG short circuit and momentary ratings. The circuit breaker will be correctly equipped with the proper code brackets but it will be necessary to replace the cell code plates so that the circuit breaker compartment will accept the higher rated replacement circuit breaker and reject all lower rated circuit breakers. When the short circuit and momentary ratings of replacement circuit breaker and the original circuit breaker are the same, no changes in the cell coding are necessary.

Figures 5.1 and 5.2 show the cell code / rejection plate mountings for the 1200 ampere and 2000 ampere circuit breakers, respectively. The tallest leg of the channel is mounted on the right hand side for the 1200 ampere circuit breaker and on the left hand side for the 2000 ampere circuit breaker. The channel is mounted to the existing studs in the floor of the circuit breaker compartment. When a cell air breaker rejection plate is not required, a shim plate is nevertheless provided to raise up the cell code plate to the correct height.

Figures 5.3 and 5.4 show the cell coding for the FC-VRG 'generator class' circuit breaker and cell, respectively. The circuit breaker will be equipped as shown; the cell code bracket will be packaged with the new circuit breaker. Mount the cell code bracket to the mounting studs in the floor of the circuit breaker compartment. The 'stick' racking track provides a reference for proper orientation of the bracket.

⚠ DANGER

FAILURE TO INSTALL THE CORRECT CELL CODING PLATES MAY ALLOW THE INCORRECT CIRCUIT BREAKER TO BE INSTALLED. CIRCUIT BREAKER AND CELL MISALIGNMENT WILL RESULT LEADING TO PROPERTY DAMAGE, BODILY INJURY AND/OR DEATH.

Figure 5.1. Cell Code / Rejection Plate Mounting (1200A)

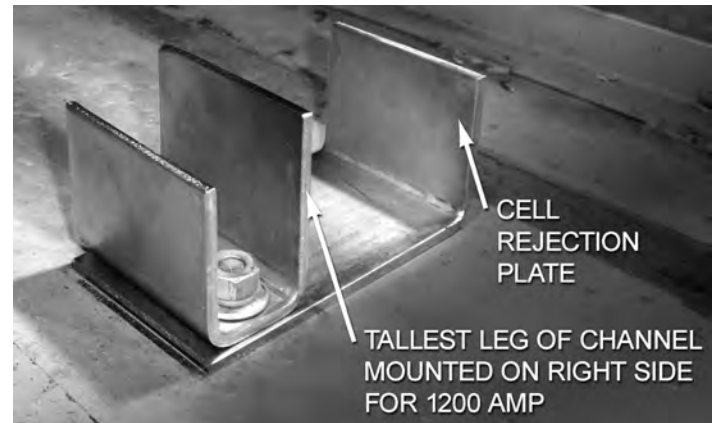


Figure 5.2. Cell Code / Rejection Plate Mounting (2000A)

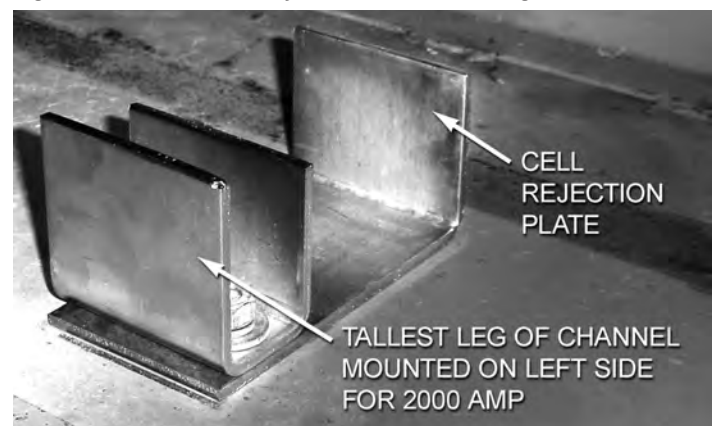


Figure 5.3. FC-VRG Code Plate Mounted on Circuit Breaker

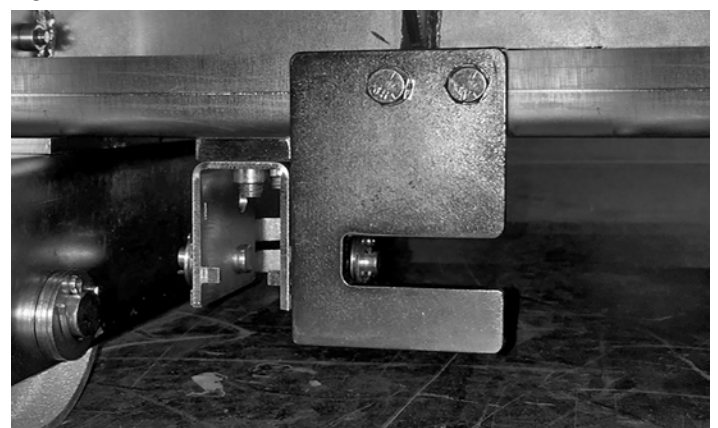


Figure 5.4. FC-VRG Code Plate Mounted in Switchgear Structure



Figure 5.5. Cell MOC Location

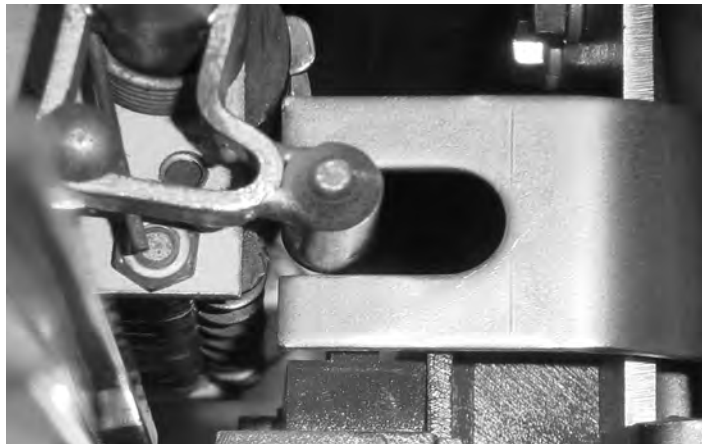


Figure 5.6. Measuring With Spring Force Gauge



5.3 SURE CLOSE MECHANISM ADJUSTMENT

⚠ WARNING

FOR ALL TYPE BREAKER HOUSINGS EQUIPPED WITH MECHANISM OPERATED CELL (MOC) SWITCHES, THE STEPS OUTLINED IN THIS SECTION MUST BE PERFORMED BEFORE INSTALLING A REPLACEMENT VR-SERIES CIRCUIT BREAKER. FAILURE TO COMPLY COULD CAUSE SEVERE PERSONAL INJURY, DEATH, EQUIPMENT DAMAGE AND/OR IMPROPER OPERATION

All type FA-VR, FB-VR, & FC-VR breakers with MOC operators utilize the **SURE CLOSE** mechanism to control kinetic energy transfer and closely mimic the dynamics and velocities of older breakers. It is imperative that this mechanism be adjusted to compensate for the force of the MOC switch mounted in the cell.

The breaker has been factory adjusted to operate a mechanism operated contact (MOC) in the cell. This means that for applications with either no MOC switch or one MOC switch, no field adjustments should be required.

The breaker has been factory adjusted to a force of 37-52 lbs., which would normally operate a well-maintained MOC assembly, with one switch.

To insure the proper operation of the **SURE CLOSE** mechanism, the MOC assembly should be cleaned and inspected for worn parts and then lubricated. A spring force gauge should be used to measure the forces needed to move the switch to the fully closed position prior to inserting the breaker (See Figure 5.6). The differential force of the

Figure 5.7. SURE CLOSE Spring Compression Adjustment

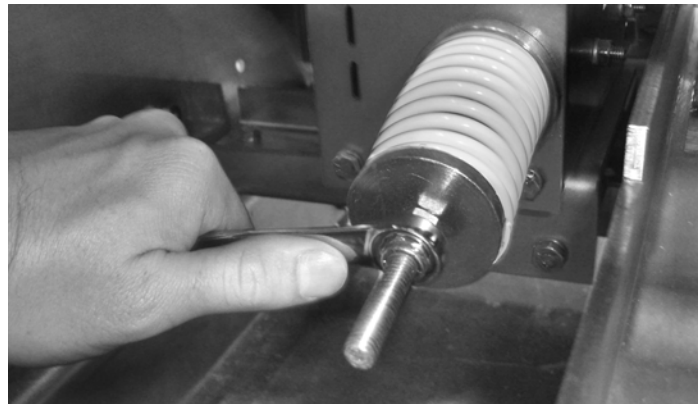
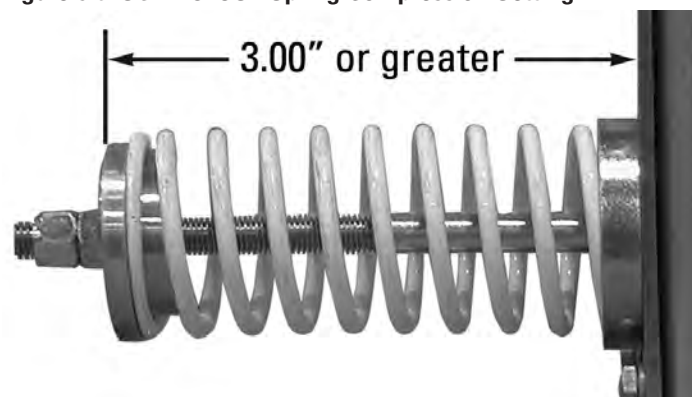


Figure 5.8. SURE CLOSE Spring Compression Setting



assembly and the breaker should be a minimum of 10 lbs. with the breaker having the higher recorded force. Should the forces be less than that, proceed with the following steps to increase the breaker force:

⚠ WARNING

MEASUREMENTS AND ADJUSTMENTS SHOULD NEVER BE ATTEMPTED IN AN ENERGIZED STRUCTURE. IF THE STRUCTURE CAN NOT BE DE-ENERGIZED, THEN PROPER PERSONAL PROTECTIVE EQUIPMENT PER NFPA 70E MUST BE WORN AT ALL TIMES WHILE GATHERING MOC SWITCH DATA, ADJUSTING OR SERVICING THE MOC SWITCH. FAILURE TO COMPLY WITH THIS WARNING COULD CAUSE SEVERE PERSONAL INJURY, DEATH, EQUIPMENT DAMAGE AND/OR IMPROPER OPERATION.

Step 1: Locate the MOC drive spring. It is located in the left lower portion of the breaker as viewed from the top rear of the breaker.

Step 2: From the factory, the drive spring comes set with adequate force to operate the MOC, however, more force can be generated. Refer to Figure 5.7 to see how that adjustment would look. Notice that there is a nut and a jam nut on the threaded rod to make the adjustment easy.

Step 3: With the breaker out of the cell, close the breaker and measure the output of the MOC drive with a spring gauge immediately after force has been recorded, open the breaker. The MOC drive force should exceed the MOC cell force requirement by a minimum of 10lbs. If not, an adjustment is required.

Step 4: Loosen the jam nut on the SURE CLOSE spring and compress the spring an additional .25 inch. Close the breaker. The minimum dimension that the spring can be tightened to is 3.00 inches as measured per Figure 5.8.

Figure 5.9. Anti-Rotation Bracket

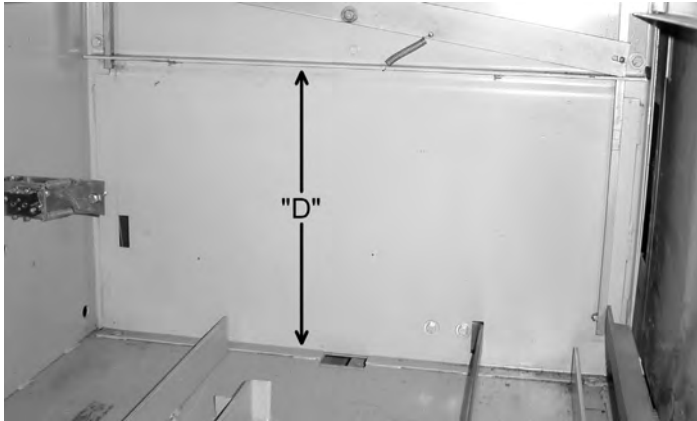


Figure 5.10. Anti-Rotation Device

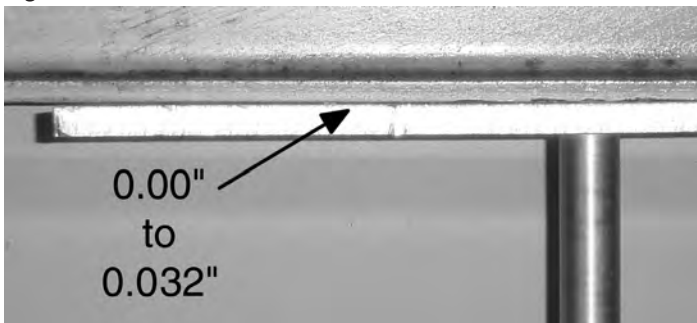


Figure 5.11. FC-VR Withdrawn From Switchgear



Step 5: Remeasure the MOC output spring force in the closed position. Repeat until the MOC forces are adequate.

Step 6: Insert into the cell.

Step 7: Operate the breaker to verify the new setting.

Step 8: Repeat steps 3 - 8 until acceptable operation is achieved.

Step 9: Anytime an adjustment is made, make sure the new compressed spring length (measured in the open position) is recorded if different than the dimension in this instruction book.

Step 10: After an adjustment is made, make sure that all nuts are secured in place, prior to returning to service.

5.4 PRE-INSTALLATION CELL CHECK

5.4.1 ANTI-ROTATION HOLD DOWNS

Measure from the floor of the cell to the bottom of the anti-rotation bracket and record measurement. (Figure 5.9, Dimension "D") With breaker out of the cell, measure from the floor to the top of the breaker's anti-rotation hold downs. (Figure Set 3.3) To adjust the hold downs loosen the nylon locknuts, move hold down, and retighten locknuts. The hold downs should still be allowed to rotate after locknuts have been tightened. There should be a gap between the hold downs and the anti-rotation bracket of no more than 0.00" - 0.032" (Figure 5.10)

5.5 SECONDARY BLOCKS

Proper secondary contact may not be possible if cell secondary blocks are not adjusted properly and cleaned periodically in accordance with manufacturer's instructions. The F-Series replacement breakers are equipped with an extra barrier/spacer between the breaker side and secondary block. This barrier/spacer can be removed if the secondary connection block of the breaker is too tight with the corresponding block of the cell. This will occur if the breaker is difficult to rack into the test position. To remove the barrier/spacer unfasten the four cylinder head screws, two at the top and two at the bottom. The barrier/spacer can be removed and the four screws reused to fasten the secondary block back into place.

⚠ WARNING

THE SECONDARY BLOCK MUST HAVE AT LEAST ONE BARRIER/SPACER BETWEEN THE TRUCK AND THE SECONDARY BLOCK. DO NOT REMOVE BOTH BARRIERS/SPACERS.

Figure 5.12. Cell Position Label Location



Figure 5.13. Cell Position Label Detail



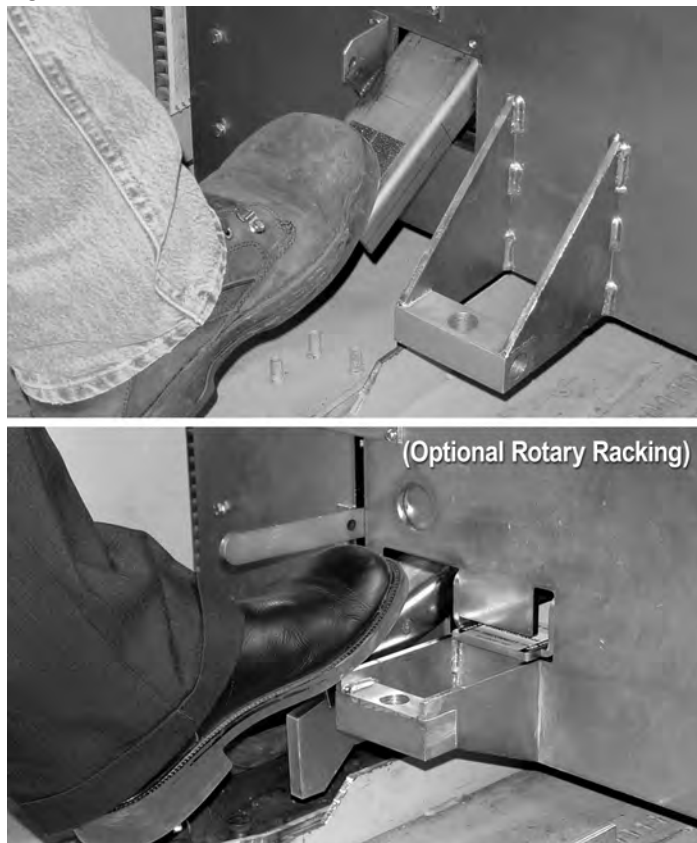
5.6 OPERATIONAL POSITIONS

Proper shutter operation requires that cell maintenance be performed in accordance with manufacturer's instructions.

The breaker has four basic operational positions:

- (1) Breaker withdrawn from cell. (Figure 5.11) In the "withdrawn" position the breaker is out of the cell or partially in the cell before the floor spring discharge interlock has activated. The levering handle is not required for this position and the levering system interlocks are not automatic outside the cell. The breaker can be operated in this position and extreme care should be exercised to avoid inadvertent operation and possible injury or equipment damage.
- (2) Breaker in the cell in the disconnect position. As the breaker is advanced into the cell, the interlock pedal will depress and activate the open linkage as the interlock plunger rides up the ramp of the cell guide rail. The floor spring discharge interlock will activate the close linkage as the front cover of the breaker breaks the plane of the cell door opening. The breaker is held open for about 9 more inches of inward travel where forward motion will halt as the floor interlock plunger engages with the cell guide rail. The interlock pedal will be depressed slightly as the interlock plunger engages. This is the "disconnect" position and the breaker can not be operated because of the interface of the interlock cam with the breakers trip linkage. Cell labeling is provided to verify this position on the right side of the cell. (See Figure 5.12 and 5.13)
- (3) Breaker in the test position. The "test" position is achieved when the breaker has advanced into the cell about 1.5 inches from the disconnect position and there is an audible click of the interlock plunger engaging the interlock rail. The secondary connection block of the breaker will have mated with the corresponding block of the cell. The test position can be verified by the inability to move the breaker in or out, the interlock pedal is in the full

Figure 5.14. Interlock Pedal



up position, and the cell label "TEST" is visible on the right side of the cell. In the test position, the breaker may be operated electrically or manually.

- (4) Breaker in the connect position. (Figure 5.16) The "connect" position is achieved by moving the breaker into the cell about 7 inches by hand and using the levering handle for about the last 2 inches of travel from the test position into the connect position, until a mechanical stop is reached. As the breaker is advanced into the cell from the test to the connect position, the primary voltage source shutters will open allowing the breaker stabs to engage with the source. This is the fully engaged or connected position. The connect position can be verified by the inability to move the breaker in or out, the interlock pedal is up, the trip mechanism has been released, and the cell label "connect" is visible on the right side of the cell. The breaker is now ready for service.

5.7 LEVERING HANDLE INSERTION AND REMOVAL PROCEDURES

5.7.1 CONVENTIONAL INSERTION PROCEDURE

- a. Place the breaker in the withdrawn position out of the cell. The levering handle is not required for this position and the levering system interlocks are not automatic outside the cell. The breaker can be operated in this position and extreme care should be exercised to avoid inadvertent operation and possible injury or equipment damage.
- b. From the withdrawn position, align the guide rail of the breaker with the guide rails of the cell.
- c. Check that the closing spring status indicator reads "DISCHARGED" and that the main contact status indicator reads "OPEN". Manually trip, close, and trip the breaker as needed to obtain this status.
- d. Push the circuit breaker into the cell until the rear wheels are on the floor and the spring discharge linkage has not cycled. No

mechanical stop will be reached. In this position the breaker can still be operated because there is no interface of the cell floor and breaker interlocks. No cell labeling is provided to verify this position.

- e. Push the circuit breaker further into the cell. Depressing the interlock pedal will make this operation easier but due to the cell design, depressing the pedal is not required at this stage.
- f. Once movement has started, the interlock pedal should be released if depressed. An audible click of the interlock plunger engaging the interlock rail will be observed at about 9 inches travel after the spring discharge linkage has cycled when the breaker enters the disconnect position. The interlock plunger will travel up at the beginning of movement and rapidly fall a short distance to lock the breaker in the disconnect position at the end of the normal travel from the withdrawn to disconnect. The movement of the pedal provides an open signal, via the interlock cams, that remains throughout all intermediate breaker positions and the cell interlock angle will force the interlock roller up and further rotate the interlock cams as the breaker breaks the cell door plane. The interlock roller, when passing the cell interlock angle, provides for a closing signal to discharge the closing springs and render the breaker trip-free. The breaker remains tripped and trip-free until the test position is reached. The disconnect position can be verified by the inability to move the breaker in or out, the interlock pedal has dropped slightly, and the cell label "DISC" is visible on the right side of the cell. The breaker is still open and forward further motion halted and rearward motion inhibited by the floor interlock plunger. This is the "disconnect" position and the breaker cannot be operated because of the interface of the interlock plunger and interlock pedal with breakers trip linkage.
- g. From the disconnect position, depress the interlock pedal and push the breaker another 1.5 inches to reach the test position.

The test position can be verified by the inability to move the breaker in or out, the interlock plunger is in the full down position, and the cell label "TEST" is visible on the right side of the cell. In the "test" position, the breaker can be operated manually and electrically, thus allowing maintenance tests or checks. The breaker is ready to operate electrically because the secondary control block is engaged automatically as the breaker advances from the disconnect to the test position and remains connected throughout further inward movement. The spring charging motor will begin to run and charge the closing spring as the trip linkage is released.

- h. To advance from the test position, depress the interlock pedal (Figure 5.14) and push the breaker by hand. At this point any attempt to mechanically close the breaker will cause a trip-free operation. As the breaker is advanced into the cell, the primary voltage source shutters will open allowing the breaker stabs to engage with the source. Although not recommended, the breaker can be pushed approximately 7 inches by hand, but the last 2 inches of travel from the test position to the connect position will require the use of the conventional levering handle to overcome the additional resistance of the primary disconnects. (See Figure 5.15)

⚠ WARNING

DO NOT ALLOW THE BREAKER TO REST IN A POSITION WHERE AUDIBLE CORONA IS EXHIBITED BETWEEN THE CELL AND BREAKER PRIMARY CONDUCTORS.

- i. Lever the breaker into the connect position by depressing the interlock pedal. The closing springs may be in the charged state but the internal PS switch will open the circuit and the close spring release coil (preventing an electrical close).

Figure 5.15. Levering In (1) and Out (2) of FC-VR Breaker

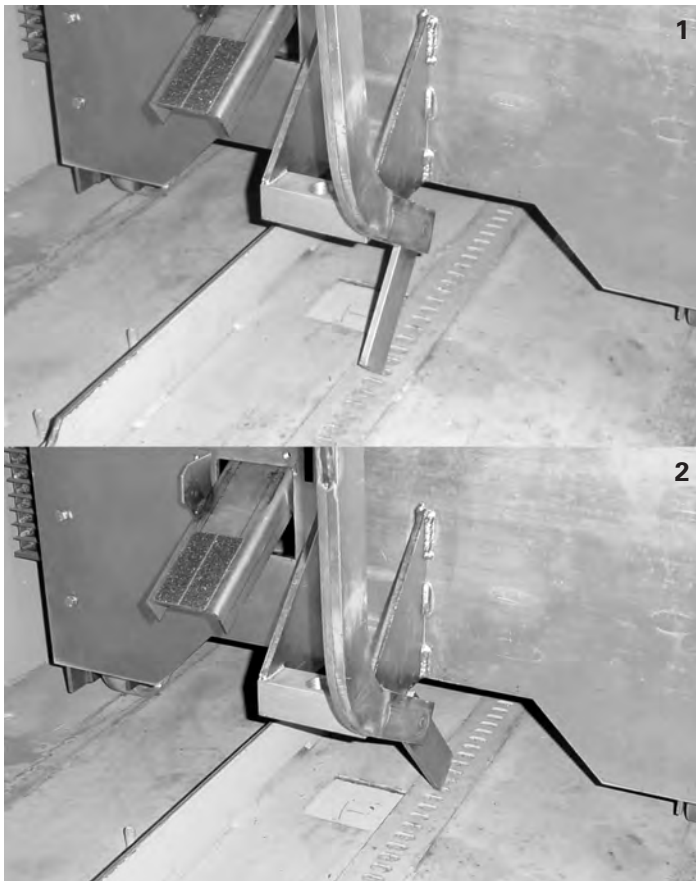


Figure 5.16. FC-VR In Connect Position



FA-VR, FB-VR, & FC-VR Replacement Circuit Breaker

- j. Continue moving the breaker into the cell using the levering handle for about 9 inches of total travel from the test position until a mechanical stop is reached. This is the fully engaged or connected position. The “connect” position can be verified by the inability to move the breaker in or out, the interlock plunger is fully down, the trip mechanism and has been released, and the cell label “CONN” (Figure 5.13) is visible on the right side of the cell. The breaker is now ready for service. (See Figure 5.16)

5.7.2 REMOVAL PROCEDURE

To remove the breaker from the cell it must be in the open position. Insure the breaker is open and engage the original levering handle. Fully depress the interlock pedal to disengage the plunger. Move the breaker out using the levering handle illustrated in Figure 4.7. The breaker will start coming out of the cell before the primary disconnects are disconnected and will be in a non-operable mode.

The breaker will go through a trip-free operation if any attempt to close it is made in the intermediate position. The shutters will close after the main stabs have cleared, isolating the breaker from its source. Continue removing the breaker until the plunger drops and locks the breaker into position. This is the test position and the trip mechanism is released, allowing the breaker to be operated either electrically or mechanically.

To remove the breaker from the test position to the disconnected position, the interlock pedal must be depressed. When moving out of the test position, the breaker will stop in the disconnect position if the interlock pedal is released as travel starts when the plunger drops into the disconnect slot of the guide rail. To further remove the breaker, the interlock pedal must be again depressed. As the breaker travels outward the last 4 inches in the cell, the mechanism will be in a trip-free condition. Once the breaker is past the floor trip activation area, it is in the withdrawn position. The breaker is now open, the closing springs are discharged, and ready to be removed from the cell if desired.

⚠ WARNING

ARC FLASH INCIDENCES WITH MV SWITCHGEAR CAN OCCUR DURING THE PROCESS OF INSERTING AND REMOVING POWER CIRCUIT BREAKERS IN SWITCHGEAR CUBICLES. IT IS STRONGLY RECOMMENDED THAT PROPER PPE (PERSONAL PROTECTIVE EQUIPMENT) BE WORN BY PERSONNEL WHO RACK BREAKERS USING THE MANUAL LEVERING HANDLE OR THE ROTARY RACKING HANDLE. EATON CORPORATION PROVIDES A UNIVERSAL REMOTE POWER RACKING SYSTEM (RPR-2) WHICH IS COMPATIBLE WITH THE INTERNAL ROTARY RACKING BREAKERS. THIS SYSTEM MAY ALLOW PERSONNEL TO WEAR A LOWER LEVEL OF PPE DURING THE INSERTION OR REMOVAL PROCESS AS LONG AS RACKING CAN BE PERFORMED FROM OUTSIDE THE FLASH PROTECTION BOUNDARY.

5.8 INTERNAL ROTARY RACKING (OPTIONAL)

5.8.1 INSERTION PROCEDURE

- a. Place the breaker in the withdrawn position (Figure 5.11); verify the breaker position indicator indicates the breaker is in the disconnect position. (Figure 5.17)

⚠ WARNING

THE BREAKER CAN BE OPERATED WHEN WITHDRAWN FROM THE CELL, HOWEVER, THE ROTARY RACKING HANDLE MUST BE USED TO RACK THE BREAKER TO THE TEST POSITION, AS SHOWN ON THE BREAKER POSITION INDICATOR. THE BREAKER MUST BE RACKED TO THE DISCONNECT POSITION, AS SHOWN ON THE BREAKER POSITION INDICATOR, BEFORE INSERTING IT INTO THE CELL.

- b. From the withdrawn position, align the guide bar of the breaker with the guide rails of the cell.

Figure 5.17. Rotary Racking Breaker Position indicator

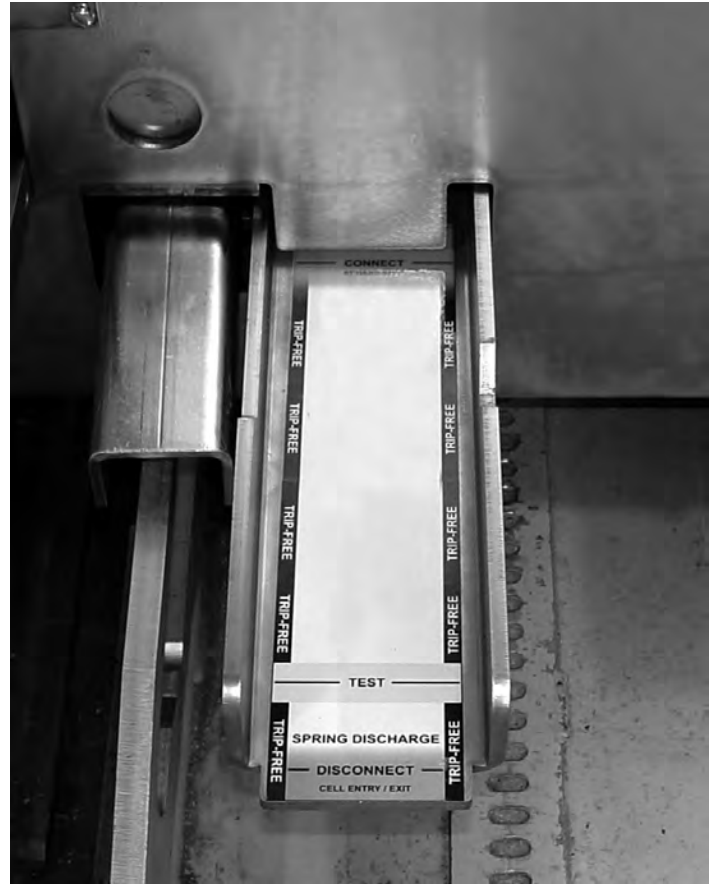
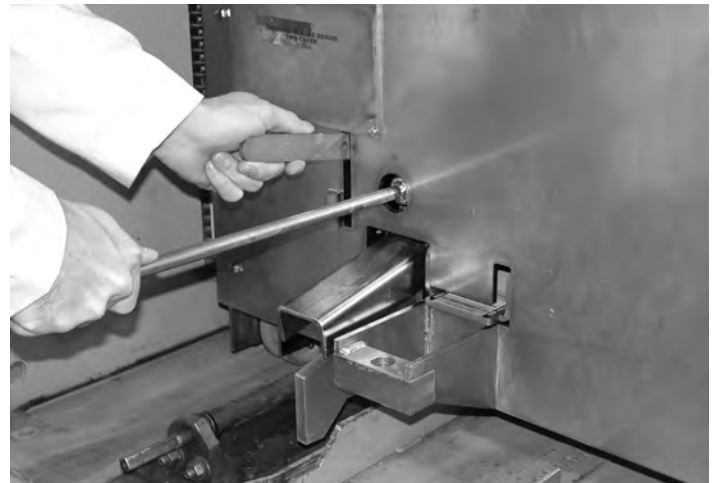


Figure 5.18. Lift Handle To Insert Rotary Racking Handle



- c. Check that the closing spring status indicator reads “DISCHARGED” and that the main contact status indicator reads “OPEN”.
- d. Push the circuit breaker into the cell until the mechanical stop is reached, this will be indicated by an audible click. At this point the front plunger has fallen into the front slot of the guide rail. In this position the breaker cannot be operated. Verify the breaker position indicator, as well as the cell position indicator, both indicate the breaker to be in the disconnect position. This position can also be verified by the ability to raise the racking access handle (Figure 5.18).

Figure 5.19. Inserting FC-VR with Internal Rotary Racking



the disconnect position, resulting in a loud noise. The breaker will be in the disconnect position when the rotary racking handle can no longer be turned with normal force, and the breaker and cell position decals indicate disconnect position. At this point, the breaker will be open with the springs discharged.

- c. If the breaker is to be withdrawn from the cell, lower the racking access handle then depress the interlock pedal while pulling the breaker out of the cell using the handles on the front of the breaker (Figure 5.14).

- e. To further advance the breaker into the cell, raise the racking access handle by pulling it up and over to the right so that it rests in the right hand side of the slot to expose the racking nut. When racking nut is exposed, insert rotary racking handle and turn clockwise. The breaker will travel approximately 1.5 inches to reach the test position. The breaker may be stopped in the test position, as indicated by the breaker and cell position decals, if electrical or mechanical testing is to be performed. Remove rotary racking handle before performing any testing.

⚠ NOTICE

ONCE THE SECONDARY DISCONNECT BLOCK IS ENGAGED IN THE "TEST" POSITION, IT WILL REMAIN CONNECTED THROUGHOUT FURTHER INWARD MOVEMENT AS THE BREAKER ADVANCES FROM THE "TEST" TO THE "CONNECT" POSITION.

THE SPRING CHARGING MOTOR WILL BEGIN TO RUN, IF THE MOTOR CUT-OFF SWITCH IS IN THE "ON" POSITION (FIGURE SET 3.3), AND CHARGE THE CLOSING SPRINGS AS THE SECONDARY CONNECTION IS MADE AS LONG AS CONTROL POWER IS AVAILABLE.

- f. From the test position, the breaker can be advanced to the connect position by reinserting the rotary racking handle. Rotate racking handle clockwise until the connect position is reached and the handle can no longer be turned. This can be verified by the breaker position indicator, as well as the cell position decal.

5.8.2 REMOVAL PROCEDURE

- a. To remove the breaker from the cell, it must be in the open position and the racking access handle in the top right slot; interlocking will prevent removal if the breaker is closed. Engage the rotary racking handle into the racking nut. Rotate the rotary racking handle counter-clockwise to move the breaker out of the cell. The shutters will start to close after the primary stabs have cleared, isolating the breaker from its source. Continue rotating racking handle counter-clockwise until the position indicators on the breaker and cell indicate test position. In test position the breaker can be operated either electrically or mechanically. Remove rotary racking handle before performing any testing.
- b. To further remove the breaker to the disconnect position continue turning the rotary racking handle in the counter-clockwise direction. If the breaker was inadvertently left charged in the test position, the springs will discharge as the breaker is racked to

SECTION 6: INSPECTION & MAINTENANCE

WARNING

DO NOT WORK ON A BREAKER IN THE "CONNECTED" POSITION.

DO NOT WORK ON A BREAKER WITH SECONDARY DISCONNECTS ENGAGED.

DO NOT WORK ON A BREAKER WITH SPRINGS CHARGED OR CONTACTS CLOSED.

DO NOT DEFEAT ANY SAFETY INTERLOCKS.

DO NOT LEAVE MAINTENANCE TOOL IN THE SOCKET AFTER CHARGING THE CLOSING SPRINGS.

WARNING

STAND AT LEAST ONE METER AWAY FROM THE BREAKER WHEN TESTING FOR VACUUM INTEGRITY.

FAILURE TO FOLLOW ANY OF THESE INSTRUCTIONS MAY CAUSE DEATH, SERIOUS BODILY INJURY, OR PROPERTY DAMAGE. SEE SECTION 2 - SAFE PRACTICES FOR MORE INFORMATION.

6.1 INSPECTION FREQUENCY

Inspect the breaker once a year when operating in a clean, non corrosive environment. For a dusty and corrosive environment, inspection should be performed twice a year. Additionally, it is recommended to inspect the breaker every time it interrupts fault current.

Note: Refer to the table below for maintenance and inspection check points.

6.2 INSPECTION AND MAINTENANCE PROCEDURES

NO. / SECTION	INSPECTION ITEM	CRITERIA	INSPECTION METHOD	CORRECTIVE ACTION IF NECESSARY		
1. Insulation	Stand Off Insulators, Operating Rods, Tie-Bars and Barriers	No Dirt	Visual Check	Clean With Lint-Free Cloth		
		No Cracking	Visual Check	Replace Cracked Unit		
	Vacuum Integrity	Between Main Circuit With Terminals Ungrounded	Withstand 27k 60Hz For 1 Minute	Hipot Tester	Clean And Retest Or Replace	
	Insulation Integrity	Main Circuit To Ground	Withstand 15kV, 60Hz For 1 Minute (5kV Rating) 27kV, 60Hz For 1 Minute (15kV Ratings)	Hipot Tester	Clean And Retest Or Replace	
Control Circuit To Ground (Charging Motor Disconnected)		Withstand 1125V, 60Hz For 1 Minute	Hipot Tester	Clean And Retest Or Replace		
2. Power Element	Vacuum Interrupters	Contact Erosion Visibility Of Mark	Visual - Close The Breaker And Look For Green Mark On Moving Stem From The Rear Of The Breaker (See Figure 6.1 and 6.2)	If Mark Is Not Visible, Replace Interrupter Assembly		
		Contact Wipe Visible	Visual (Figure 6.3 and 6.4)	Replace VI Assembly		
		Adequate Vacuum	See Section 6.3	Replace Interrupter Assembly If Vacuum Is Not Adequate		
		Dirt On Ceramic Body	Visual Check	Clean With Dry Lint-Free Cloth		
	Primary Disconnects	No Burning Or Damage	Visual Check	Replace If Burned, Damaged Or Eroded		
3. Control Circuit Parts	Closing And Tripping Devices Including Disconnects	Smooth And Correct Operation By Control Power	Test Closing And Tripping Of The Breaker Twice	Replace Any Defective Device-Identify Per Trouble-Shooting Chart		
	Wiring	Securely Tied In Proper Place	Visual Check	Repair Or Tie As Necessary		
	Terminals	Tight	Visual Check	Tighten Or Replace If Necessary		
	Motor	Smooth And Correct Operation By Control Power	Test Closing And Tripping Of The Breaker Twice	Replace Brushes Or Motor		
	Tightness Of Hardware	No Loose Or Missing Parts	Visual And Tightening With Appropriate Tools	Tighten Or Reinstate If Necessary		
4. Operating Mechanism	Dust Or Foreign Matter	No Dust Or Foreign Matter	Visual Check	Clean As Necessary		
	Lubrication	Smooth Operation And No Excessive Wear	Sight And Feel	Lubricate Very Sparingly With Light Machine Oil		
	Deformation Or Excessive Wear	No Excessive Deformation Or Wear	Visual And Operational	Remove Cause And Replace Parts		
	Manual Operation	Smooth Operation	Manual Charging Closing And Tripping	Correct Per Trouble-Shooting Chart If Necessary		
	CloSure™ Test	≥ 0.6 Inch Over Travel	CloSure™ Test 6.8.1	If < 0.6 Contact P.B.C. At 1-877-276-9379		
BOLT SIZE	8 - 32	10 - 32	.25 - 20	.31 - 18	.38 - 16	.50 - 13
TORQUE Lb. In.	24	36	72	144	300	540

6.3 VACUUM INTERRUPTER INTEGRITY TEST

Vacuum interrupters used in Type VR-Series circuit breakers are highly reliable interrupting elements. Satisfactory performance of these devices is dependent upon the integrity of the vacuum in the interrupter and the internal dielectric strength. Both of these parameters can be readily checked by a one minute AC high potential test. (See Table 6.1 for appropriate test voltage.) During this test, the following warning must be observed:

⚠ WARNING

APPLYING ABNORMALLY HIGH VOLTAGE ACROSS A PAIR OF CONTACTS IN VACUUM MAY PRODUCE X-RADIATION. THE RADIATION MAY INCREASE WITH THE INCREASE IN VOLTAGE AND/OR DECREASE IN CONTACT SPACING. X-RADIATION PRODUCED DURING THIS TEST WITH RECOMMENDED VOLTAGE AND NORMAL CONTACT SPACING IS EXTREMELY LOW AND WELL BELOW MAXIMUM PERMITTED BY STANDARDS. HOWEVER, AS A PRECAUTIONARY MEASURE AGAINST POSSIBILITY OF APPLICATION OF HIGHER THAN RECOMMENDED VOLTAGE AND/OR BELOW NORMAL CONTACT SPACING, IT IS RECOMMENDED THAT ALL OPERATING PERSONNEL STAND AT LEAST ONE METER AWAY IN FRONT OF THE BREAKER.

With the breaker open and securely sitting on the floor, connect all top/front primary studs (bars) together and the high potential machine lead. Connect all bottom/rear studs together and the high potential return lead. Do not ground them to the breaker frame. Start the machine at zero potential, increase to appropriate test voltage and maintain for one minute.

Successful withstand indicates that all interrupters have satisfactory vacuum level. If there is a breakdown, the defective interrupter or interrupters should be identified by an individual test and replaced before placing the breaker in service.

After the high potential is removed, discharge any electrical charge that may be retained, particularly from the center shield of vacuum interrupters. To avoid any ambiguity in the AC high potential test due to leakage or displacement (capacitive) current, the test unit should have sufficient volt-ampere capacity. It is recommended that the equipment be capable of delivering 25 milliamperes for one minute.

Although an AC high potential test is recommended, a DC test may be performed if only a DC test unit is available, but is not recommended.

In this case the equipment must be capable of delivering 5 milliamperes for one minute to avoid ambiguity due to field emission or leakage currents and the test voltage shall be as shown in Table 6.1.

The current delivery capability of 25 mA AC and 5 mA DC apply when all three VI's are tested in parallel. If individual VI's are tested, current capability may be one third of these values.

⚠ WARNING

SOME DC HIGH POTENTIAL UNITS, OPERATING AS UNFILTERED HALF-WAVE RECTIFIERS, ARE NOT SUITABLE FOR USE TO TEST VACUUM INTERRUPTERS BECAUSE THE PEAK VOLTAGE APPEARING ACROSS THE INTERRUPTERS CAN BE SUBSTANTIALLY GREATER THAN THE VALUE READ ON THE METER.

Breaker Rated Maximum Voltage	Vacuum Interrupter Integrity Test Voltage	
	AC 60Hz	DC
Up to and including 15.0 kV	27 kV	40 kV

6.4 CONTACT EROSION AND WIPE

Since the contacts are contained inside the interrupter, they remain clean and require no maintenance. However, during high current interruptions there may be a minimal amount of erosion from the contact surfaces. To determine contact erosion, close the breaker and observe the vacuum interrupter moving stem from the rear of the breaker. If the mark on each stem is visible, erosion has not reached maximum value thus indicating satisfactory contact surface of the interrupter. If the mark is not visible, the vacuum interrupter assembly must be replaced (Figure 6.1 and 6.2).

The adequacy of contact wipe can be determined by simply observing the vacuum interrupter side of the operating rod assembly on a closed breaker. Figures 6.3 and 6.4 show the procedure for determining the contact wipe. It maybe necessary to use a small mirror and flashlight to clearly see the "T" shape indicator. If the wipe is not adequate, the vacuum interrupter assembly (Pole Unit) must be replaced. Field adjustment is not possible.

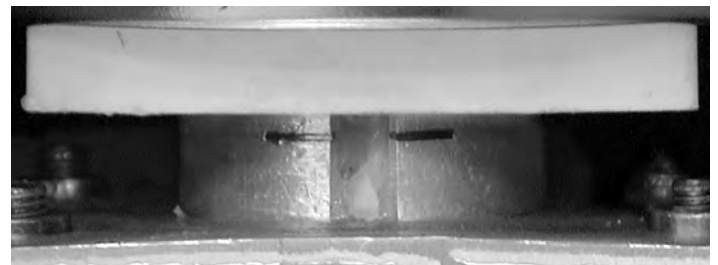
⚠ WARNING

FAILURE TO REPLACE A VACUUM INTERRUPTER ASSEMBLY WHEN CONTACT EROSION MARK IS NOT VISIBLE OR WIPE IS UNSATISFACTORY, WILL CAUSE THE BREAKER TO FAIL TO INTERRUPT AND THEREBY CAUSE PROPERTY DAMAGE OR PERSONNEL INJURY.

Figure 6.1. Vacuum Interrupter Showing Contact Erosion Indicator With Breaker Open (Shown here for clarity purposes only)



Figure 6.2. Vacuum Interrupter Showing Contact Erosion Indicator With Breaker Closed (Indicators are checked only when breaker is closed.)



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Figure 6.3. The Arrow Shows The “T” Contact Wipe Indicator - Example with Blue Spring (If the “T” or any portion of its visible as shown with the breaker closed, the wipe is satisfactory) (See Next Figure for Graphic of All Possibilities)



6.5 INSULATION

In VR-Series breakers, insulation maintenance primarily consists of keeping all insulating surfaces clean. This can be done by wiping off all insulating surfaces with a dry lint free cloth or dry paper towel. In case there is any tightly adhering dirt that will not come off by wiping, it can be removed with a mild solvent or distilled water. But be sure that the surfaces are dry before placing the breaker in service. If a solvent is required to cut dirt, use Isopropyl Alcohol or commercial equivalent. Secondary control wiring requires inspection for tightness of all connections and damage to insulation.

6.6 INSULATION INTEGRITY CHECK

PRIMARY CIRCUIT:

The integrity of primary insulation may be checked by the AC high potential test. The test voltage depends upon the maximum rated voltage of the breaker. For the breakers rated 4.76 kV, 8.25 kV and 15 kV the test voltages are 15 kV, 27 kV and 27 kV RMS, 60 Hz respectively. Conduct the test as follows:

Close the breaker. Connect the high potential lead of the test machine to one of the poles of the breaker. Connect the remaining poles and breaker frame to ground. Start the machine with output potential at zero and increase to the test voltage. Maintain the test voltage for one minute. Repeat for the remaining poles. Successful withstand indicates satisfactory insulation strength of the primary circuit.

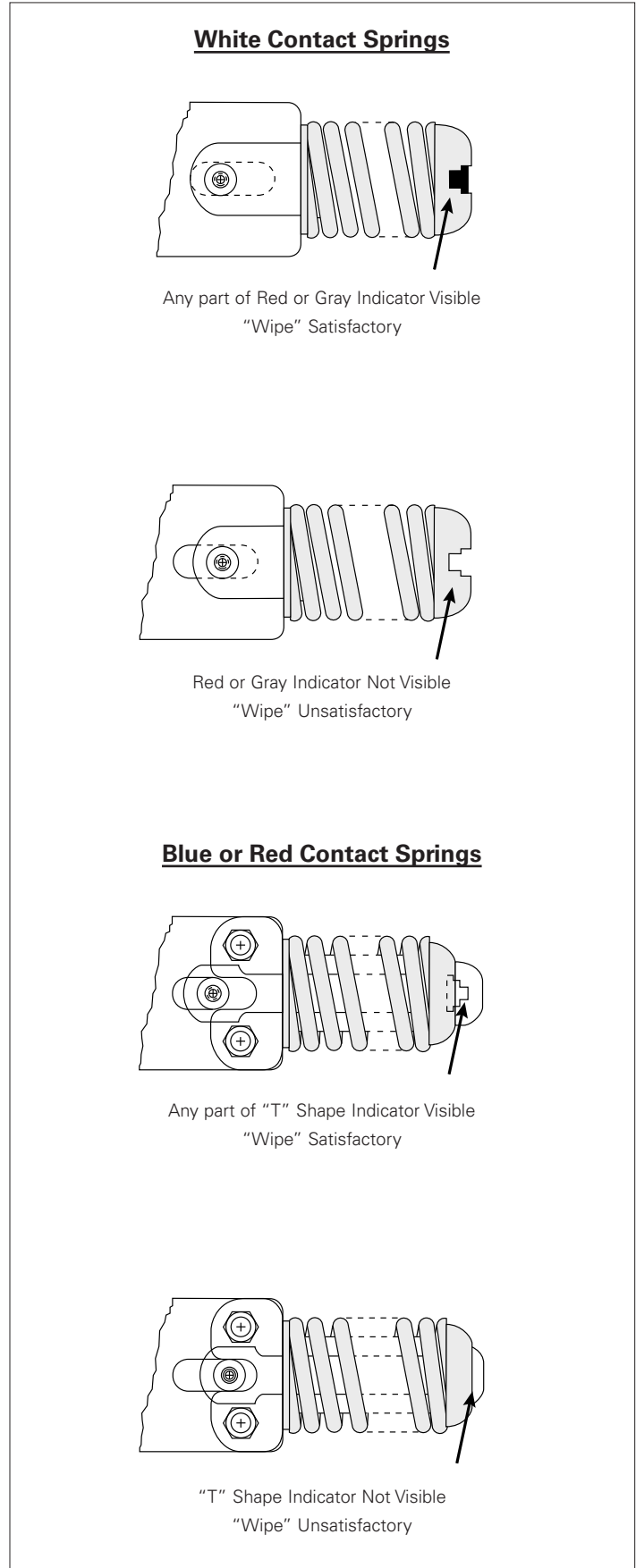
Open the breaker. Connect the high potential lead of the test machine to one of the poles of the breaker. Connect the remaining poles and breaker frame to ground. Start the machine with output potential at zero and increase to the test voltage. Maintain the test voltage for one minute. Repeat for the remaining poles. Successful withstand indicates satisfactory insulation strength of the primary circuit.

If a DC high potential machine is used, make certain that the peak voltage does not exceed the peak of the corresponding AC RMS test voltage.

SECONDARY CIRCUIT:

Isolate the motor by disconnecting the two motor leads from the terminal block. Connect all points of the secondary disconnect pins with a shooting wire. Connect this wire to the high potential lead of the test machine. Ground the breaker frame. Starting with zero, increase the voltage to 1125 RMS, 60 Hz. Maintain the voltage for one minute. Successful withstand indicates satisfactory insulation strength of the secondary control circuit. Remove the shooting wire and reconnect the motor leads.

Figure 6.4. Wipe Indication Procedure (Performed Only With Breaker Closed)



6.7 PRIMARY CIRCUIT RESISTANCE CHECK

The main contacts of the VR-Series circuit breaker are inside the vacuum chamber where they remain clean and require no maintenance at any time. Unlike most typical circuit breaker designs, the VR-Series design uses a highly reliable and unique flexible clamp design that eliminates the need for lubrication and inspection for wear.

The DC electrical resistance of the primary circuit may be calculated by measuring the voltage drop across the circuit. This test should be performed with a low voltage, direct current (DC) power supply capable of delivering no less 100A DC.

- To check the primary circuit resistance:
- Remove the circuit breaker from the switchgear
- Close the breaker
- Pass at least 100A DC from terminal to terminal of each pole unit in the closed position
- Measure the voltage drop across the terminals.

The resistance can be calculated from Ohm's Law and is expressed in micro-ohms. Repeat for the remaining two poles.

The resistance should not exceed the factory test levels more than 200%. Factory test levels are recorded on the circuit breaker test form, which is included with the breaker. If measurements exceeds 200%, contact the manufacturer.

Resistance conversion for Temperature

$$R_{\text{conversion}} = R_{\text{Factory}}(1 + (T_{\text{Field}} - T_{\text{Factory}})\rho)$$

$R_{\text{conversion}}$ = Resistance correction for temperature based from the factory resistance measurement.

R_{Factory} = Resistance measurement from the factory.

T_{Field} = Temperature measurement in the field.

T_{Factory} = Temperature measurement from the factory.

ρ = Copper resistivity temperature coefficient.

$\rho = 0.0039$ Copper Resistivity Temperature Coefficient / Deg C

$\rho = 0.002167$ Copper Resistivity Temperature Coefficient / Deg F

6.8 MECHANISM CHECK

Make a careful visual inspection of the mechanism for any loose parts such as bolts, nuts, pins, rings, etc. Check for excessive wear or damage to the breaker components. Operate the breaker several times manually and electrically. Check the closing and opening times to verify that they are in accordance with the limits in Table 4.1.

6.8.1 CLOSURE™ TEST

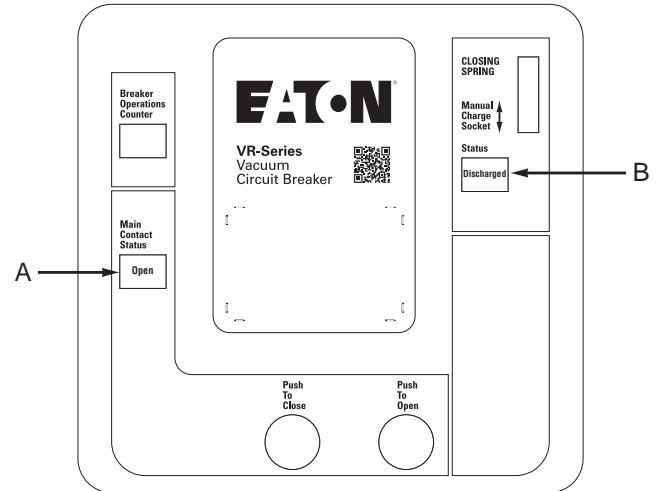
Introduction: The CloSure™ Test is a simple yet extremely effective means to determine and monitor the ability of the mechanism to close the breaker contacts fully. It provides a quantitative measure of the extra energy available in terms of over travel in inches to close the breaker contacts to their full extent. It may be used periodically to monitor the health of the mechanism.

General Information: The CloSure™ Test can be performed on all VR-Series circuit breakers. (Refer to Table 6.1.) If the CloSure™ travel obtained is as specified, the mechanism performance is satisfactory. If the CloSure™ travel does not conform as shown in Figure 6.15, contact Eaton's Electrical Services & Systems for further information. (See Step 13).

⚠ WARNING

DO NOT ATTEMPT TO INSTALL OR PERFORM MAINTENANCE OR TESTS ON THE EQUIPMENT WHILE IT IS ENERGIZED. NEVER PUT YOUR HANDS NEAR THE MECHANISM WHEN THE CIRCUIT BREAKER IS IN THE CHARGED OR CLOSED POSITION. DEATH OR SEVERE PERSONAL INJURY CAN RESULT FROM CONTACT WITH ENERGIZED EQUIPMENT. ALWAYS VERIFY THAT NO VOLTAGE IS PRESENT BEFORE PROCEEDING WITH THE TASK, AND ALWAYS FOLLOW GENERALLY ACCEPTED SAFETY PROCEDURES.

Figure 6.5. Status Indicators ("A" shows the contact status indication and "B" shows the spring indication.)



Safety Precautions: Read and understand these instructions before attempting any maintenance, repair or testing on the breaker. The user is cautioned to observe all recommendations, warnings and cautions relating to the safety of personnel and equipment.

The recommendations and information contained herein are based on Eaton Electrical experience and judgment, but should not be considered to be all-inclusive or covering every application or circumstance which may arise. If further information is required, you should consult Eaton's Electrical Services & Systems.

Testing Procedures: Assuming that the circuit breaker is safely removed from the switchgear enclosure and positioned in an area outside the arc fault boundary, follow this procedure to perform the CloSure™ test. For further instructions on removal of the circuit breaker from the switchgear, refer to the appropriate section of this manual.

Step 1 - On the front cover, identify the status indicators. Make sure the closing spring status indicates "DISCHARGED" and the main contact indicator shows "OPEN" (Figure 6.5).

Step 2 - Remove the circuit breaker front cover. Be sure to save the original fasteners for reassembly.

Step 3 - Charge the circuit breaker, close the circuit breaker, then open the circuit breaker. Alternately depress the Open and Close clappers a few times to ensure the circuit breaker is completely discharged.

Step 4 - Cut a piece of one inch wide drafting / masking tape approximately 8 to 10 inches long.

Figure 6.6. Wrapping Tape Around Cam



FA-VR, FB-VR, & FC-VR Replacement Circuit Breaker

Step 5 - Clean the far left cam with a mild solvent such as alcohol. Place the tape around the cam starting from the bottom up. Make certain that the tape adheres well to the cam surface. (Figure 6.6).

Step 6 - Mount the transparent CloSure™ Test Tool (Figure 6.7b) with two bolts and washers. Refer to Figure 6.7a and Table 6.1 for approximate mounting holes. Hand tighten the bolts.

Step 7 - Using a red Sanford® Sharpie® fine point permanent marker (or equivalent), place the marker tip in the proper hole ("C") located over the cam and make a heavy mark on the tape by moving the marker as described in Figures 6.9, 6.11, and 6.12. Remove the marker from the hole.

Step 8 - Charge the closing springs with the maintenance tool (Charging handle). Continue charging the closing springs until a "click" is heard and the status indicator shows "CHARGED" (Figure 6.8).

Step 9 - Place the marker back in the hole. While holding the marker tip against the tape, close the breaker (Figure 6.10). Remove the marker from the hole.

Step 10 - While closely observing the pole shaft at the right side of the circuit breaker (Figure 6.11), recharge the closing springs with the maintenance tool. As the circuit breaker is recharged, there should be no movement of the pole shaft. If there is movement of the pole shaft while recharging, this indicates a problem with the circuit breaker - stop the test and consult the factory.

Step 11 - Open the circuit breaker, then close it, then reopen it. Verify that the mark made in Step 7 is aligned with the pen opening. If it is not aligned, this indicates a problem with the circuit breaker - stop the test and consult the factory.

Step 12 - Inspect the circuit breaker to assure it is in the open position and the closing springs are discharged. Alternately depress the Open and Close clappers a few times to ensure the circuit breaker is completely discharged. Remove the transparent CloSure™ Tool.

Step 13 - Remove the tape from the cam and place it on a sheet of paper that can be kept as a record of the test. Record the date of the test, person conducting the test, circuit breaker serial number, and the operations counter on the tape or paper (Figures 6.14 and 6.15).

Step 14 - Evaluate the CloSure™ performance by comparing the test tape with the illustration in Figure 6.16. Measure the over travel "X". If "X" is not greater than or equal to 0.6", this indicates a problem with the circuit breaker - consult the factory.

Step 15 - Reassemble the front cover onto the circuit breaker. Return the circuit breaker to its original configuration and setup.

Figure 6.7. Attaching CloSure™ Test Tool at Hole "A" & "B"

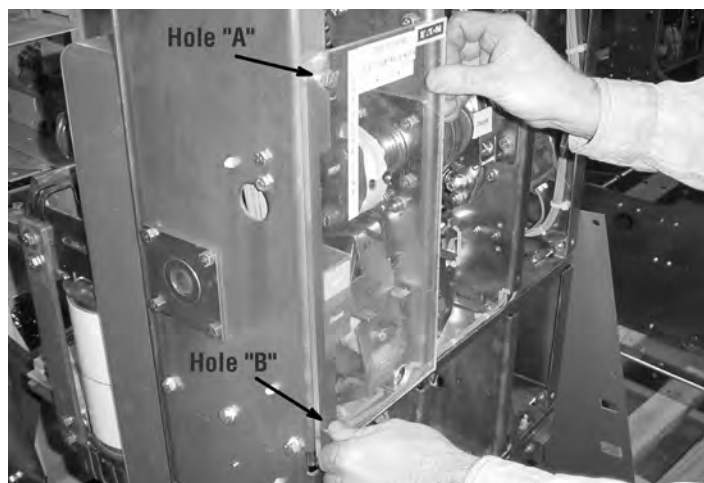


Figure 6.7b. Front View of CloSure™ Tool Showing Mounting / Testing Hole Locations (6352C49H01)

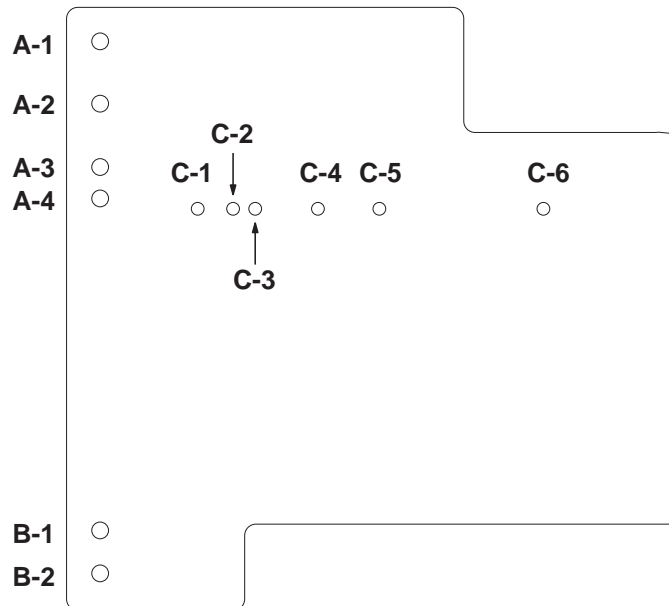


Table 6.1. CloSure™ Tool Mounting/Testing Locations by Circuit Breaker Type

BREAKER LINE	APPROXIMATE MECHANISM CABINET WIDTH (INCH)	UPPER MOUNTING HOLE	LOWER MOUNTING HOLE	MARKER PLACEMENT HOLE
18WR	18	A1	B2	C1
20WR	20	A1	B2	C2
29WR	27	A1	B2	C5

Figure 6.7c. Typical Circuit Breaker Front View with CloSure™ Tool Attached (Approximate Mechanism Chassis Width)

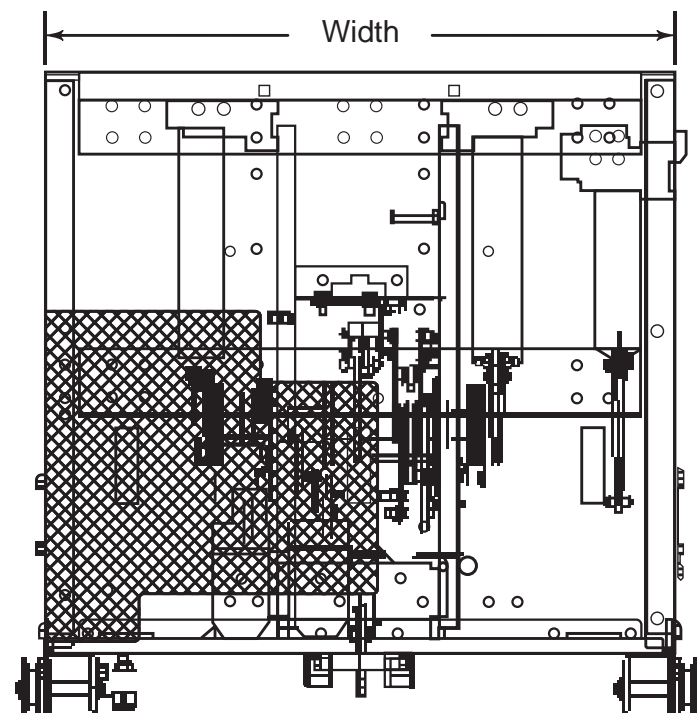


Figure 6.8. Manually Charging Closing Springs

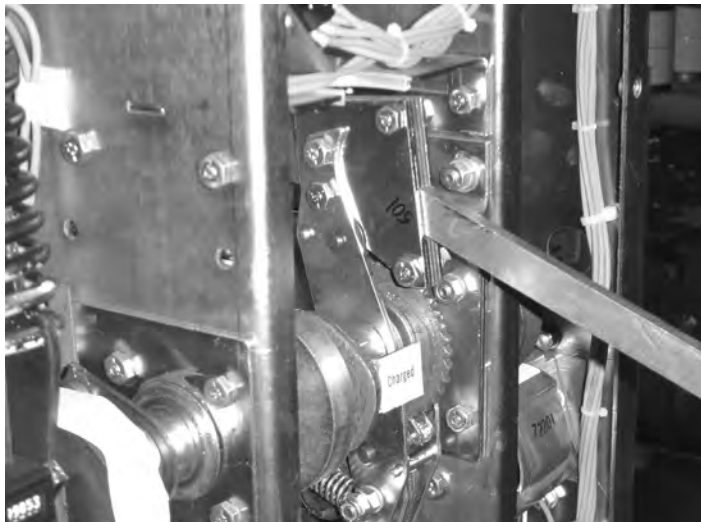


Figure 6.9. Make a Clear and Heavy Mark



Figure 6.10. With Marker in Hole "C", While Closing Breaker



Figure 6.11. Pole Shaft Located On Right Side Of Circuit Breaker

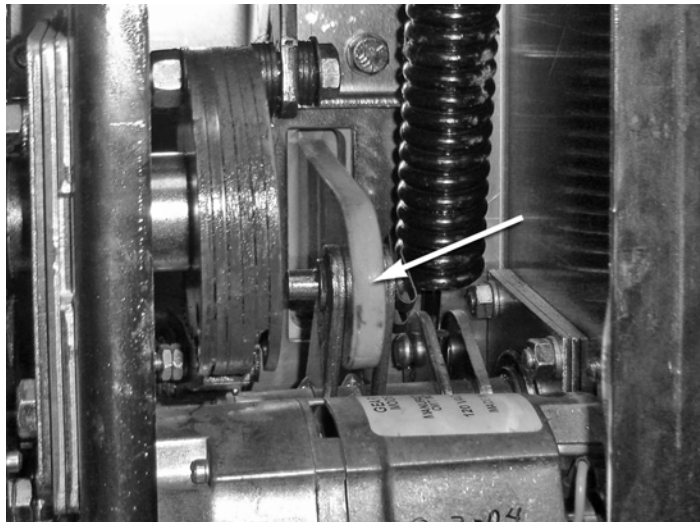


Figure 6.12. Move the Sharpie® 15° Left and Right



Figure 6.13. Top view of Cam and Marker Interface

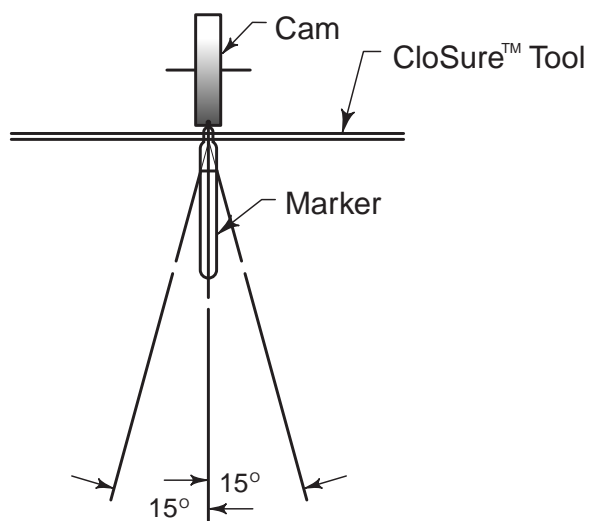


Figure 6.14. Evaluate the CloSure™ Performance

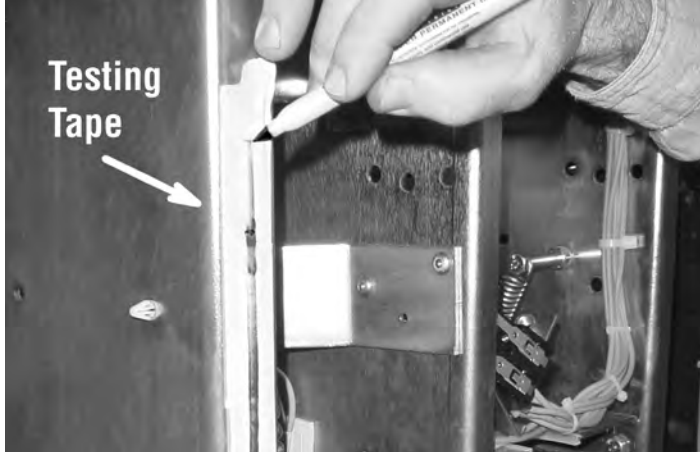
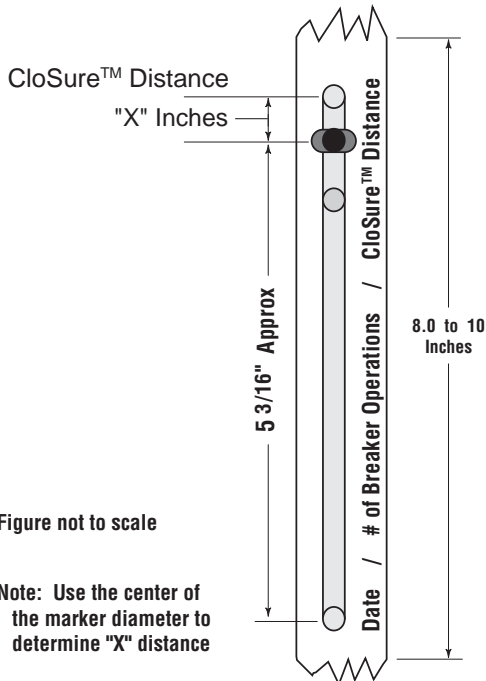


Figure 6.15. Determining the Distance Traveled



Figure 6.16. Illustrative Testing Tape Sample



6.9 LUBRICATION

All parts that require lubrication have been lubricated during the assembly with molybdenum disulphide grease. Eaton No. 53701QB. Over a period of time, this lubricant may be pushed out of the way or degrade. Proper lubrication at regular intervals is essential for maintaining the reliable performance of the mechanism. **The breaker should be relubricated once a year or per the operations table (Table 6.2), which ever comes first.** The locations shown in Figure 6.17 should be lubricated with a drop of light machine oil.

After lubrication, operate the breaker several times manually and electrically.

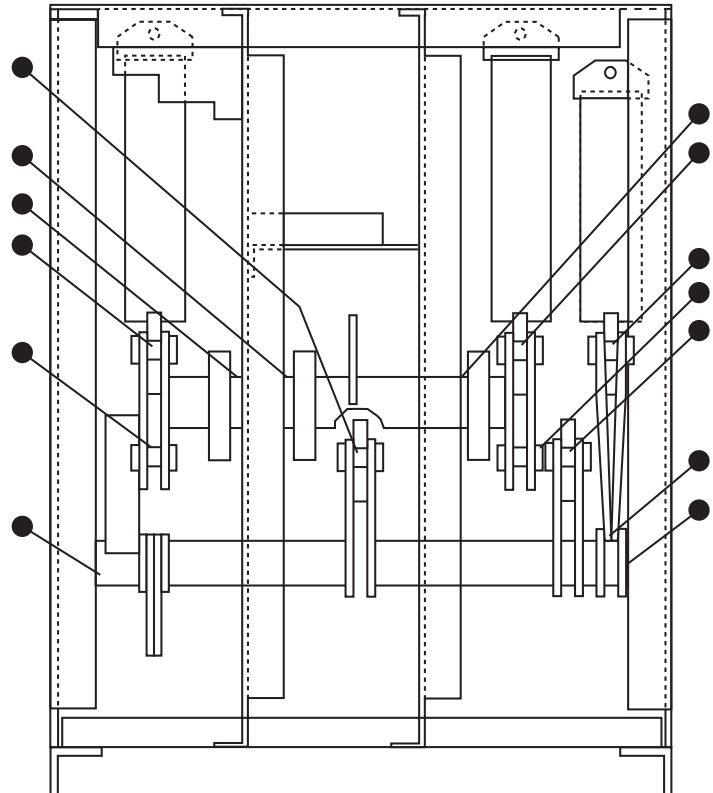
Roller bearings are used on the pole shaft, the cam shaft, the main link and the motor eccentric. These bearings are packed at the factory with a top grade slow oxidizing grease which normally should be effective for many years. They should not be disturbed unless there is definite evidence of sluggishness, dirt or parts are dismantled for some reason.

If it becomes necessary to disassemble the mechanism, the bearings and related parts should be thoroughly cleaned, remove old grease in a good grease solvent. Do not use carbon tetrachloride. They should then be washed in light machine oil until the cleaner is removed. After the oil has been drawn off, the bearings should be packed with Eaton Grease 53701 QB or equivalent.

Table 6.2. Lubrication Per Number of Operations

RATINGS	OPERATIONS
29kA and below	750
Above 29kA	400
3000 Amp	400

Figure 6.17. General Lubrication Areas



● Apply one drop of non-synthetic light machine oil at locations shown.

Table 6.3. Troubleshooting Chart

SYMPTOM	INSPECTION AREA	PROBABLE DEFECTS
FAILS TO CLOSE		
Closing Springs Not Charged	Control Circuit	<ul style="list-style-type: none"> Control Power (Fuse Blown Or Switch Off) Secondary Disconnects Motor Cut-off Switch (Poor Or Burned Contacts. Lever Not Operational.) Terminals And Connectors (Poor Or Burned Contacts) Motor (Brushes Worn Or Commutator Segment Open)
	Mechanism	<ul style="list-style-type: none"> Pawls (Slipping Or Broken) Ratchet Wheel (Teeth Worn Or Broken) Cam Shaft Assembly (Sluggish Or Jammed) Oscillator (Reset Spring Off Or Broken)
Closing Springs Not Charged Breaker Does Not Close	Control Circuit (Close Coil Does Not Pick Up)	<ul style="list-style-type: none"> Control Power (Fuse blown or switch off) Secondary Disconnects Anti Pump Relay (Y Relay N.C. Contact Open Or Burned Or Relay Picks Up) Close Coil (Open Or Burned) Latch Check Switch (Contact Open - Bad Switch Or Trip Bar Not Reset) Auxiliary Switch (B Contact Open Or Burned) Motor Cut-Off (Contacts Open Or Burned) Trip Coil Assembly (Clapper Fails To Reset)
	Closing Sound But No Close	<ul style="list-style-type: none"> Pole Shaft (Not Open Fully) Trip Latch Reset Spring (Damaged Or Missing) Trip Bar-D Shaft (Fail To Remain Reset) Trip Latch-Hatchet (Fails To Remain Reset) Trip Floor Tripper (Fails To Remain Reset) Close Latch (Binding) Close Latch Roller (Binding) Trip Circuit Energized
UNDESIRABLY CLOSES		
	Control Circuit	<ul style="list-style-type: none"> Close Circuit (CS/C Getting shorted)
	Mechanism	<ul style="list-style-type: none"> Close Release Latch (Fails To Reset) Close Floor Tripper (Fails To Reset)
FAILS TO CLOSE		
No Trip Sound	Control Circuit	<ul style="list-style-type: none"> Control Power (Fuse Blown Or Switch Off) Secondary Disconnects Auxiliary Switch (A Contact Not Making Poor Or Burned) Trip Coil (Burned Or Open) Terminals And Connections (Poor Or Burned Or Open) Trip Clapper (Jammed)
	Trip Mechanism	
Trip Sound But No Trip	Trip Mechanism	<ul style="list-style-type: none"> Trip Bar, Trip Latch (Jammed) Pole Shaft (Jammed) Operating Rod Assembly (Broken Or Pins Out)
	Vacuum Interrupter (One Or More Welded)	
UNDESIRABLY TRIPS		
	Control Circuit	<ul style="list-style-type: none"> Control Power (CS/T Switch, remains made)
	Mechanism	<ul style="list-style-type: none"> Trip Coil Clapper (Not Resetting) Trip Bar or Trip Latch (Poor Engagement Of Mating Or Worm Surfaces) Trip Bar Reset Sprint (Loss Of Torque)

SECTION 7: REPLACEMENT PARTS











7.1 GENERAL

In order to minimize production downtime, it is recommended that an adequate quantity of spare parts be carried in stock. The quantity will vary from customer to customer, depending upon the service severity and continuity requirements. Each customer should develop his own level based on operating experience. However, when establishing a new operating record, it is a good practice to stock one set of control components for every six circuit breakers of the same control voltage. This quantity should be adjusted with time and frequency of operation of the circuit breakers.

7.2 ORDERING INSTRUCTIONS

- The style numbers in Table 7.1 should be sufficient to purchase control components for most applications. Some breakers have special control schemes. Supply complete nameplate information for verification or if additional components are needed.
- Specify the method of shipping desired.
- Send all orders or correspondence to the nearest Eaton sales office or contact the PBC direct at 1-877-276-9379.
- Include negotiation number with order when applicable.

Table 7.1 Common Replacement Parts - Descriptions and Style Numbers

<p>1. ANTI-PUMP (Y) RELAY</p> 	<p>(48vDC) (125vDC) (250vDC) (120vAC) (240vAC)</p>	<p>94C9525H01 94C9525H02 94C9525H03 94C9525H04 94C9525H05</p>	<p>6. BREAKER POSITION SWITCH</p>  <p>Breaker Position Switch PS2 94C9525H07</p>
<p>2. RECTIFIER</p> 	<p>Rectifier</p>	<p>94C9525G09</p>	<p>7. LATCH CHECK SWITCH</p>  <p>Latch Check Switch (LC) 94C9525H08</p>
<p>3. SPRING CHARGING MOTOR</p> 	<p>(48vDC) (125vDC) (250vDC / 240vAC)</p>	<p>94C9525G10 94C9525G11 94C9525G12</p>	<p>8. MOTOR CUTOFF SWITCHES</p>  <p>(LS) (20WR/29WR) (LS) (18WR) 94C9525G14 94C9525G15</p>
<p>4. BREAKER AUXILIARY SWITCH</p> 	<p>Breaker Auxiliary Switch</p>	<p>94C9525G13</p>	<p>9. SPRING RELEASE COILS / SHUNT TRIPS</p>  <p>24vDC 48vDC 125vDC / 120vAC 250vDC / 240vAC 94C9525G16 94C9525G17 94C9525G18 94C9525G19</p>
<p>5. BREAKER POSITION SWITCH</p> 	<p>Breaker Position Switch PS1</p>	<p>94C9525H06</p>	<p>10. CONTROL COMPONENTS KIT</p>  <p>48vDC 125vDC 250vDC 120vAC-C/M 48vDC-T 240vAC-C/M 48vDC-T 120vAC-C/M 120vAC-CT 240vAC-C/M 240vAC-CT 94C9525G01 94C9525G02 94C9525G03 94C9525G04 94C9525G05 94C9525G06 94C9525G07</p>



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