SECTION 1: INTRODUCTION

The purpose of this book is to provide instructions for receiving and handling, storage, installation, operation and maintenance of the General Electric type VB1 VR-Series+ circuit breaker. The Vacuum Replacement Circuit Breakers (also referred to as VR-Series+) are designed to be used in existing VB1 metal-clad switchgear and provide equal or 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 REPRESENTATIVE SHOULD BE CONTACTED.

1.1 AVAILABLE VB1-VR+ CIRCUIT BREAKERS

Refer to Table 1.

Table 1. VB1-VR+ Availability and Interchangeability

Existing VB1 Circuit Circuit Breaker Type	VB1-VR+ Circuit Breaker Type ①	Maximum Voltage	Nominal 3-Phase MVA Class	Existing Circuit Breaker Rated Continuous Current at 60 Hz	Rated Voltage Factor ④	Rated Withstand ANSI Test Voltage		Rated Short-Circuit	Maximum Sym. Interrupting Capability	Closing and Latching / Momentary Capabilities
		kV	MVA	Amps	K	Low Freq. kV RMS	Impulse kV Peak	I kA RMS	KI kA RMS	kA RMS / Peak
VB1-4.16-250	VB1-VR+250	4.76	250	1200 / 2000	1.25	19	60	29	36	58 / 97
VB1-4.16-250	VB1-VR+4.16-41 ②③	4.76	N/A	1200 / 2000	1.00	19	60	41	41	78 / 132
VB1-7.2-500	VB1-VR+7.2-500	8.25	500	1200 / 2000	1.25	36	95	33	41	66 / 111
VB1-13.8-500	VB1-VR+13.8-500	15	500	1200 / 2000	1.30	36	95	18	23	37 / 62
VB1-13.8-500	VB1-VR+13.8-41 ②③	15	N/A	1200 / 2000	1.00	36	95	41	41	78 / 132
VB1-13.8-750	VB1-VR+750	15	750	1200 / 2000	1.30	36	95	28	36	58 / 97
VB1-13.8-750	VB1-VR+13.8-41 ②③	15	N/A	1200 / 2000	1.00	36	95	41	41	78 / 132

① All circuit breakers have a 3 second short-time and 3-cycle interrupting ratings.
② Non-standard rating.
③ Requires bus bracing study and additional switchgear bracing.
④ All ratings were tested to multiple versions of IEEE C37.09 and can be rated as K=1 or K>1

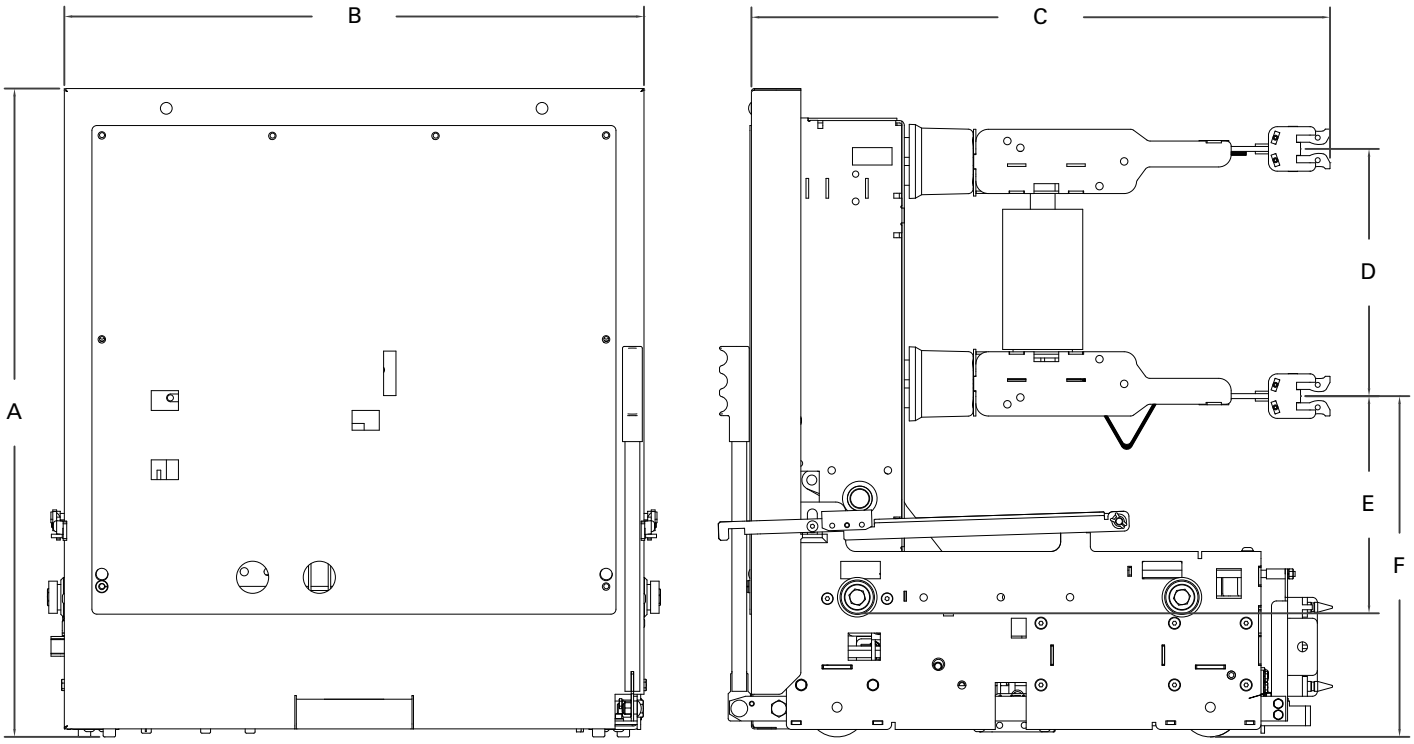


Table 2. VB1-VR+ Dimensions

Breaker Type	Existing Breaker Rated Continuous Current at 60 Hz (Amps)	A	B	C	D	E	F
VB1-VR+	1200 / 2000	32.79	29.31	29.26	12.50	10.98	17.23

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 TEST 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 VB1 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, (if applicable) 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 tool is provided with each vacuum unit replacement breaker. (Style# 8064A02G01)

Racking Handle: The racking handle is used to drive the racking mechanism which moves the circuit breaker into and out of the cell. The original OEM racking handle will interface switchgear racking mechanism therefore not provided as part of the vacuum replacement breaker.

Secondary Connection Block Extension Cable: An 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. The original OEM extension cable will interface with the VR-Series+ replacement breaker therefore an additional extension cable is not included as part of the vacuum replacement breaker.

Figure 3.1. Typical Manual Charge Handle

3.2 HANDLING

⚠ WARNING

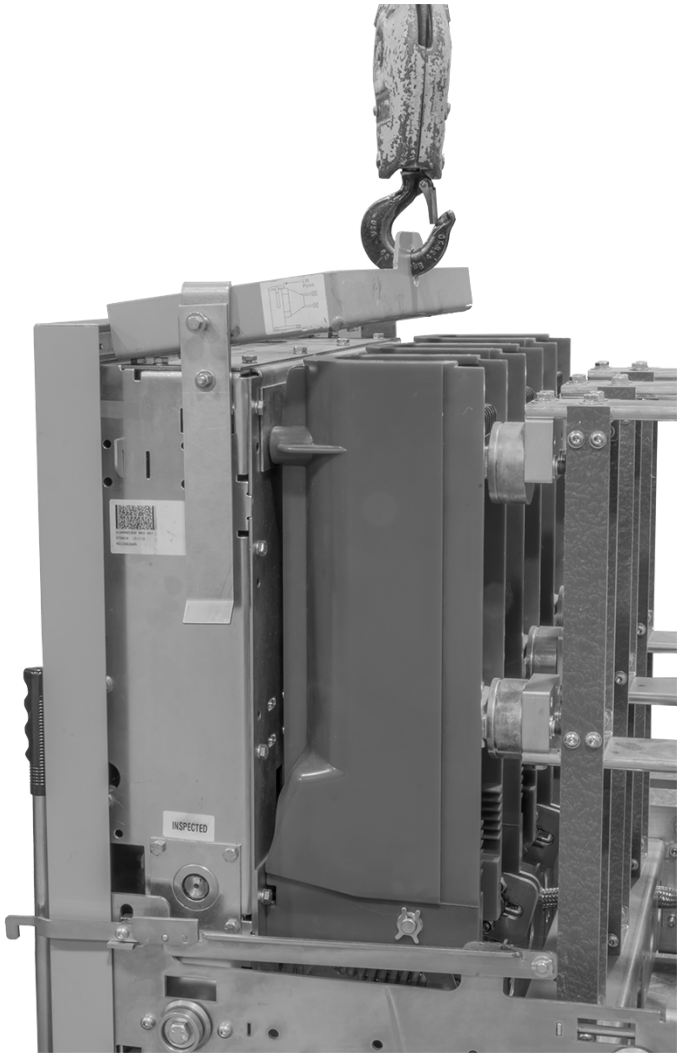
DO NOT USE ANY LIFTING DEVICE AS A PLATFORM FOR PERFORMING MAINTENANCE, REPAIR OR ADJUSTMENT OF THE BREAKER OR FOR OPENING, CLOSING THE CONTACTS OR CHARGING THE SPRINGS. THE BREAKER MAY SLIP OR FALL CAUSING SEVERE PERSONAL INJURY. ALWAYS PERFORM MAINTENANCE, REPAIR AND ADJUSTMENTS ON A WORKBENCH CAPABLE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

VR-Series+ 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. Lifting VB1-VR+



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 3.3, 3.5, & 3.7). 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.

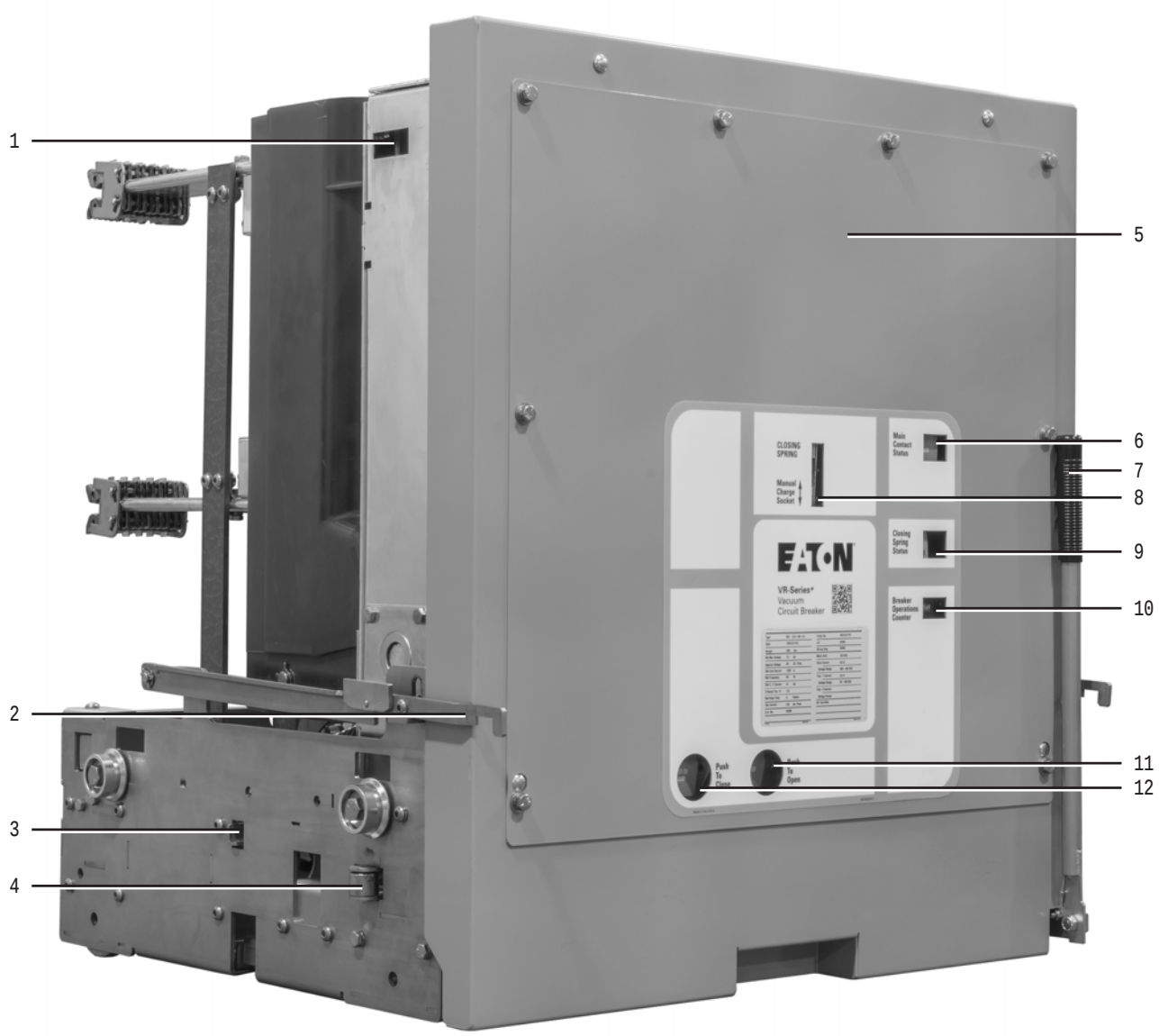
3.4 VB1-VR+ APPROXIMATE WEIGHTS

Refer to Table 3.

Table 3. Maximum Weight by Type

Type	Amperes	LBs
VB1-VR+	1200	520
VB1-VR+	2000	570

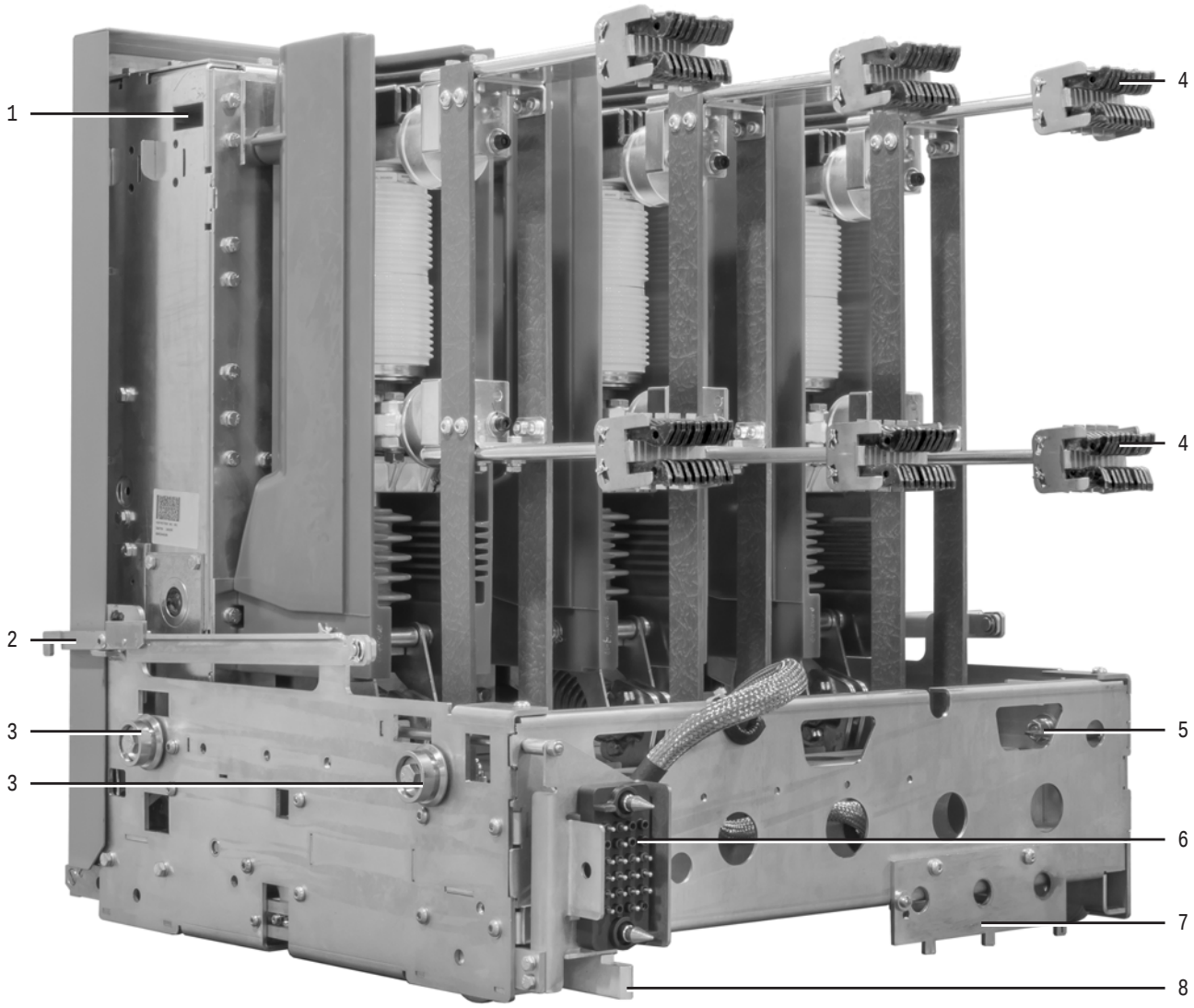
Figure 3.3.a. Front External View of VB1-VR+ (1200A, 41kA Shown)



Front External View

1	Lifting Point	5	Removable Front Cover	9	Spring Charged / Discharged Indicator
2	Racking Latch	6	Breaker Status Indicator	10	Operations Counter
3	Passive Interlock	7	Secondary Disconnect Engagement Handle	11	Push To Open Button
4	Active Interlock	8	Manual Charging Socket	12	Push To Close Button

Figure 3.3.b. Rear External View of VB1-VR+ (1200A, 41kA Shown)



Rear External View

1	Lifting Point	5	Lock-Out Provision
2	Stored Energy Disharge Interlock	6	Secondary Disconnect
3	Track Rollers	7	Code Plate
4	Primary Disconnect	8	Ground Contact

SECTION 4: DESCRIPTION AND OPERATION

VR-Series+ vacuum replacement circuit breakers are designed to be used with existing installations of equivalent air-magnetic metal-clad switchgear circuit breakers. 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 if the vapor leaves the contact area, it would condense 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 VACUUM INTERRUPTER ASSEMBLY

Each vacuum interrupter assembly (also referred to as pole unit) is assembled at the factory as a unit to assure correct dimensional relationships between working components. Three interrupter assemblies are used per circuit breaker. Each vacuum interrupter assembly consists of a molded insulator frame and includes the vacuum interrupter, its lead assembly, bell crank, operating rod, stand-off insulator, and contact load spring. The vacuum interrupter is mounted vertically with the stationary vacuum interrupter stem upward and the moving interrupter stem downward. The pole units are fastened to the circuit breaker's stored energy mechanism frame. Silver-plated copper laminated shunts transfer current from the moving interrupter stem to the upper primary bushings via a Holm-free, non-sliding conical current transfer. A silver-plated copper casting is attached to the stationary stem, completing the primary circuit to the lower disconnect assemblies. The operating rod, loading spring, and bell crank transfer the mechanical motion from the circuit breaker's stored energy mechanism to the moving stem of the vacuum interrupter.

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 copper-chrome contact material. The VR-Series+ vacuum interrupter assembly incorporates both the original vacuum interrupter erosion indicator and the contact-spring wipe into one all-encompassing indicator. The adequacy of the remaining contact erosion and wipe can easily be determined by observing the moving end of the vacuum interrupter assembly on a closed circuit breaker. The procedure to determine the adequacy of the "T" cutout on the vacuum interrupter assembly is depicted in Figures 6.1 and 6.2. If the wipe is inadequate (no part of the "T" cutout is visible) then the vacuum interrupter assembly must be replaced. Field adjustment is not possible.

Figure 4.1. Vacuum Interrupter Assembly

Figure 4.2. Vacuum Interrupter Assembly (All Three Pole Units)

⚠ DANGER

FAILURE TO REPLACE THE VACUUM INTERRUPTER ASSEMBLY WHEN INDICATED BY THE CONTACT EROSION INDICATOR COULD CAUSE THE CIRCUIT BREAKER TO FAIL, LEADING TO DEATH, SEVERE PERSONAL INJURY, EQUIPMENT DAMAGE AND/OR IMPROPER OPERATION.

4.1.3 CONTACT WIPE AND STROKE

The circuit breaker mechanism provides a fixed amount of motion to the operating rods connected to the moving stem of the vacuum interrupter. The first portion of the motion, the stroke, is used to close the vacuum interrupter contacts; the remainder of that motion, the wipe, is used to further compress the pre-loaded wipe spring. Contact stroke and wipe are related; contact wipe is the indication of the force holding the vacuum interrupter contacts closed as well as the energy available to hammer the contacts open with sufficient speed for interruption. Stroke is the gap between the stationary and moving contact of the vacuum interrupter when the circuit breaker is open. As the stroke increases due to contact erosion inside the vacuum interrupter, the wipe decreases. Although these changes are taking place as operations accumulate on the vacuum interrupter, field adjustment of the wipe or stroke are not necessary during the lifetime of the vacuum interrupter.

⚠ 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 LINE AND LOAD CONDUCTOR ASSEMBLIES

Multiple finger type primary disconnecting contacts at the ends of the conductors provide means for connecting and disconnecting the circuit breaker to the bus terminals in the circuit breaker compartment of the metal-clad switchgear.

4.3 STORED ENERGY MECHANISM

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

The mechanism stores the closing energy by charging the closing springs. Spring charging is automatically accomplished when control power is applied to the circuit breaker secondary disconnect contact. When released, the stored energy closes the circuit 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:

a. Circuit Breaker open, closing springs discharged.

b. Circuit Breaker open, closing springs charged.

c. Circuit Breaker closed, closing springs discharged.

d. Circuit Breaker closed, closing springs charged.

The mechanism is a mechanically "trip-free" design. Trip-free is defined in Section 4.3.4 (Trip-Free Operation).

In normal operation the closing spring is charged by the spring charging motor, and the circuit 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 circuit breaker can be closed and tripped by pushing the "Push to Close" and "Push to Open" operators on the front cover.

⚠ DANGER

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

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

ELECTRICAL TRIPPING CAN BE VERIFIED WHEN THE CIRCUIT BREAKER IS IN THE 'DISCONNECT / TEST' POSITION.

4.3.1 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 end of the maintenance tool into the manual charge socket opening and charge the closing springs by moving the handle up and down the full range of motion. When charging is complete the ratchet will no longer advance and the spring charged / discharged indicator displays 'Charged'. (Figure Set 3.3). Any further motion of the maintenance tool will not result into advance of charging.

4.3.2 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 circuit breaker is open and the closing springs are not charged. In this state, the trip latch (8) is disengaged from the trip "D" shaft (9) (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 lower portion of the clapper pushes the spring release latch (1) downward. 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 circuit breaker closed.

Figure 4.8.d shows the circuit 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.

4.3.3 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 lower. 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 circuit breaker is tripped open.

4.3.4 TRIP-FREE OPERATION

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

4.4 CONTROL SCHEMES

There are two basic control schemes for the VR-Series+ circuit breaker elements, one for dc control and one for ac control voltages (Figure 4.4). Specific customer order wiring schematics and diagrams are included with each circuit breaker.

There may be different control voltages or more than one tripping device, 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 circuit breaker may be closed by closing the control switch close (CS/C) contact. Automatically upon closing of the circuit breaker, the motor starts charging the closing springs. The circuit breaker may be tripped any time by closing the control switch (CS/T) contacts.

Note the position switch (PS1) contact in the spring release circuit in the scheme. This contact remains closed while the circuit breaker is being racked between the 'Test' and 'Connect' positions for VR-Series+ circuit breakers. Consequently, it prevents the circuit breaker from closing automatically, even though the control close contact may have been closed while the circuit breaker is racked to the 'Connect' position.

When the CS/C contact is closed, the SR closes the circuit breaker. If the CS/C contact is maintained after the circuit 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 circuit breaker would subsequently open, it could not be reclosed before CS/C was released and remade. This is the anti-pump function.

4.4.1 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 circuit breaker. Typical ranges as observed using nominal control voltages are listed in Table 4.

Table 4. Time Per Event

Event	Milliseconds
Closing Time (From Initiation of Close Signal to Contact Make)	45 - 60
Opening Time (Initiation of Trip Signal to Contact Break)	30 - 38
Reclosing Time (Initiation of Trip Signal to Contact Make)	140 - 165

Note: Values are typical at nominal rated control voltage(s).

4.6 SECONDARY CONNECTION BLOCK

The circuit breaker control circuit is connected to the switchgear control using a handle located to the right of the circuit breaker. The secondary disconnects are in the lower left hand corner when facing the rear of the circuit breaker. With the circuit breaker in the 'test' position, the handle can be folded down and pushed inward to engage the stationary secondary disconnects in the circuit breaker compartment. These contacts remain engaged when the circuit breaker is racked to the 'connect' position. The secondary disconnects can be manually disconnected when the circuit breaker is returned to the 'test' position prior to removal from the circuit breaker compartment.

Figure 4.2. Vacuum Interrupter Assembly (All Three Pole Units)