Instruction Bulletin - 01.4IB.51200D
PowlVac-AR® Arc Resistant Switchgear

5kV & 15kV
1200A, 2000A, 3000A, & 4000A Forced Cooled
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Signal Words

As stated in ANSI Z535.4-2007, the signal word is a word that calls attention to the safety sign and designates a degree or level of hazard seriousness. The signal words for product safety signs are “Danger”, “Warning”, “Caution”, and “Notice”. These words are defined as:

![DANGER]

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

![WARNING]

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

![CAUTION]

CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

![CAUTION]

CAUTION, used without the safety alert symbol, is used to address practices not related to personal injury.

![NOTICE]

NOTICE is used to address practices not related to personal injury.

Qualified Person

For the purposes of this manual, a qualified person, as stated in NFPA 70E®, is one who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved. In addition to the above qualifications, one must also be:

1. trained and authorized to energize, deenergize, clear, ground, and tag circuits and equipment in accordance with established safety practices.
2. trained in the proper care and use of personal protective equipment (PPE) such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.
3. trained in rendering first aid if necessary.
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Ch 1 General Information

⚠️ **WARNING**

The equipment described in this document may contain high voltages and currents which can cause death or serious injury.

The equipment is designed for use, installation, and maintenance by knowledgeable users of such equipment having experience and training in the field of high voltage electricity. This document and all other documentation shall be fully read, understood, and all warnings and cautions shall be abided by. If there are any discrepancies or questions, the user shall contact Powell immediately at 1.800.480.7273.

⚠️ **WARNING**

Prior to adjustments, servicing, maintenance, or any act requiring the operator to make physical contact with the equipment, the power source must be disconnected and the equipment grounded. Failure to do so may result in death or serious injury.

**NOTICE**

The information in this instruction bulletin is not intended to explain all details or variations of the Powell equipment, nor to provide for every possible contingency or hazard to be met in connection with installation, testing, operation, and maintenance of the equipment. For additional information and instructions for particular problems, which are not presented sufficiently for the user’s purposes, contact Powell at 1.800.480.7273.

**NOTICE**

Powell reserves the right to discontinue and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.
A. Scope

The information in this instruction bulletin describes the following PowlVac-AR® Medium Voltage Arc Resistant Switchgear assemblies:

- 5kV - 1200A, 2000A, 3000A Convection Cooled, & 4000A Forced Cooled
- 15kV - 1200A, 2000A, 3000A Convection Cooled, & 4000A Forced Cooled

Standard construction details are provided in the appropriate sections of this instruction bulletin. The circuit breaker element operation and maintenance instructions can be found in the circuit breaker operating instruction manual provided with each circuit breaker. Any special switchgear construction details are provided in supplementary documentation.

B. Purpose

The information in this instruction bulletin is intended to provide details required to properly install, operate, and maintain the PowlVac-AR Arc Resistant Switchgear described in Ch 1 General Information, A. Scope.

This instruction bulletin provides:

1. Safety guidelines
2. General descriptions of the operation and maintenance of the PowlVac-AR Arc Resistant Switchgear
3. Instructions for installation and placing the switchgear into service
4. Instructions for part replacement
5. Information for ordering renewal parts
6. Illustrations, photographs, and description of the switchgear

The illustrations contained in this document may not represent the exact construction details of each particular type of metal-clad switchgear. The illustrations in this document are provided as general information to aid in showing component locations only.

All illustrations and photos are shown using deenergized equipment.

WARNING

Follow the appropriate safety precautions while handling any of the equipment. Failure to do so may result in death or serious injury.

To the extent required, the products described herein meet the applicable ANSI, IEEE, and NEMA Standards; however, no such assurance is given with respect to local codes and ordinances which may vary greatly.

C. Instruction Bulletins Available Electronically

Changes to the instruction bulletin may be implemented at any time and without notice. Go to powellind.com to ensure use of the current instruction bulletin for Powell equipment.

For more information visit powellind.com. To contact the Powell Service Division call 1.800.480.7273 or 713.944.6900, or email info@powellservice.com.

For specific questions or comments pertaining to this instruction bulletin, email documents@powellind.com with the IB number in the subject line.
D. ASSOCIATED BULLETINS

- 01.4IB.51051C Electric Remote Racking Device (51899G10)
- 01.4IB.51056B PowlVac® ARM Automatic Racking Mechanism Vacuum Circuit Breaker
- 01.4IB.51808A Vacuum Type Remote Racking Device (51897G29)
- 01.4IB.60203 PowlVac® CDA Vacuum Circuit Breaker
- 01.4IB.60303 PowlVac® CDA 63kA Vacuum Circuit Breaker
- 01.4IB.60305 PowlVac® CDR & GCB Series 4 Vacuum Circuit Breakers
Ch 2 Safety

A. Safe Work Condition

The information in Section A is quoted from NFPA 70E 2012 - Article 120, 120.1 Establishing an Electrically Safe Work Condition.

120.1 Process of Achieving an Electrically Safe Work Condition

1. Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.
2. After properly interrupting the load current, OPEN the disconnecting device(s) for each source.
3. Wherever possible, visually verify that all blades of the disconnecting devices are fully OPEN or that drawout type circuit breakers are withdrawn to the fully disconnected position.
4. Apply lockout/tagout devices in accordance with a documented and established policy.
5. Use an adequately rated voltage detector to test each phase conductor or circuit part to verify they are deenergized. Test each phase conductor or circuit part both phase-to-phase, and phase-to-ground. Before and after each test, determine that the voltage detector is operating satisfactorily.

Informational Note: See ANSI/ISA-61010-1 (82.02.01)/UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements, for rating and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 V and below.

6. Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

B. Safety Guidelines

Study this instruction bulletin and all other associated documentation before installing the switchgear.

Each user has the responsibility to instruct and supervise all personnel associated with usage, installation, operation, and maintenance of this equipment on all safety procedures. Furthermore, each user has the responsibility of establishing a safety program for each type of equipment encountered.

The circuit breakers used in the metal-clad switchgear described in this instruction bulletin are operated by a high-energy, high-speed mechanism that is interlocked to provide specific operating sequences. It is mandatory that the following rules be observed to ensure the safety of personnel associated with usage, installation, operation, and maintenance of these circuit breakers.

The safety rules in this instruction bulletin are not intended to be a complete safety program. The rules are intended to cover only some of the important aspects of personnel safety related to PowlVac-AR® Arc Resistant Metal-Clad Switchgear.
C. **General**

1. Only supervised and qualified personnel trained in the usage, installation, operation, and maintenance of the switchgear shall be allowed to work on this equipment. It is mandatory that this instruction bulletin, any supplements, and service advisories be studied, understood, and followed.

2. Maintenance programs must be consistent with both customer experience and manufacturer’s recommendations, including service advisories and instruction bulletin(s). A well planned and executed routine maintenance program is essential for circuit breaker’s reliability and safety.

3. Service conditions and circuit breaker applications shall also be considered in the development of safety programs. Variables include ambient temperature; humidity; actual continuous current; thermal cycling; number of operations; interrupting duty; and any adverse local conditions including excessive dust, ash, corrosive atmosphere, vermin and insect infestations.

4. PowlVac-AR® Switchgear is designed to operate with the access doors to high voltage components closed. If a circuit breaker or auxiliary component is removed for any reason, the door must be re-closed and properly secured.

D. **Specific**

1. **Do not work on energized PowlVac-AR switchgear.** If work must be performed on the switchgear, remove it from service and place it in an electrically safe condition.

2. **Do not work on an energized circuit breaker.** If work must be performed on a circuit breaker, remove the circuit breaker from service by removing it from the switchgear. **Do not leave the circuit breaker compartment door open.**

3. **Extreme care must be exercised to keep all personnel, tools, and other objects clear of mechanisms which are to be operated, discharged, or released.** These circuit breakers utilize stored energy mechanisms. These mechanism must be serviced only by skilled and knowledgeable personnel capable of releasing each spring load in a controlled manner. Detailed information regarding these mechanisms is found in the circuit breaker instruction bulletin.

4. **Do not attempt to close the circuit breaker manually on an energized circuit.**

5. **Do not use an open circuit breaker as the sole means of isolating a high voltage circuit.** For complete isolation, the circuit breaker shall be in the disconnected position or shall be withdrawn completely.

6. **All components shall be disconnected by means of a visible break and securely grounded for safety of personnel performing maintenance operations on the PowlVac-AR switchgear, circuit breakers, or connected equipment.**
7. Closed-door operation features on the PowlVac-AR® allow both circuit breakers and auxiliary devices to be connected to or disconnected from the power circuit with the compartment door closed. Maintenance functions to either device will require opening the compartment door to remove the device. Opening the compartment door with the bus energized removes the arc resistant features of the design. Personal Protective Equipment (PPE) suitable for the potential exposure hazard must be worn if the operator opens any high voltage compartment door while the equipment is energized. Maintenance operations, such as fuse replacement on the auxiliary device, require opening the compartment door. While it is common practice to replace fuses in auxiliary devices with the equipment energized, this practice is not recommended.

8. Interlocks are provided to ensure the proper operating sequences of the PowlVac-AR switchgear, circuit breakers and for the safety of the user. If for any reason an interlock does not function as described, do not make any adjustments, modification, or deform the parts. Do not force the parts into position. Contact Powell for further instructions.

E. X-Rays

When high voltage is applied across the contacts of a vacuum interrupter, there is the possibility of generation of X-rays. The intensity of the X-radiation is dependent on the peak voltage and the contact gap. At the normal operating voltage for this type of equipment, the radiation levels are negligible. At the voltages specified for testing, test personnel shall be in front of the circuit breaker such that the two layers of steel used in the frame and front cover construction are between the test personnel and the vacuum interrupters, and that the test personnel be no closer than one meter (3’) from the front of the circuit breaker. The circuit breaker shall be either fully open, or fully closed when making high potential tests. Do not test with contacts partially open.

F. Safety Labels

The equipment described in this document has DANGER, WARNING, CAUTION, and instruction labels attached to various locations. All equipment DANGER, WARNING, CAUTION, and instruction labels shall be observed when the equipment is handled, operated, or maintained.

**NOTICE**

Warning and Caution labels are located in various places. Do NOT remove or deface any of these warning/caution labels.
Ch 3  Equipment Description

A. General

**NOTICE**

*Powell is committed to continuous product improvement.*

*It is possible that improvements occurred between revisions to this document and therefore, may not be described in these instructions. If the equipment does not resemble the photographs and descriptions contained herein, do not attempt to perform any actions. Contact the Powell Service Division.*

PowlVac-AR® Arc Resistant Switchgear is defined as switchgear that is designed to withstand an internal arcing fault and able to direct the flow of the resulting gases and debris away from adjacent equipment and operating personnel.

PowlVac-AR switchgear is used to protect and control medium voltage, alternating current power distribution systems. The arc resistant design combines circuit breakers, auxiliary devices, and switchgear structures that are completely designed and fabricated by Powell. The circuit breaker design incorporates vacuum interrupters utilizing chrome copper contacts. The switchgear design incorporates an optional plenum and exhaust vents, double walls between sections, reinforced door assemblies, and both electrical and mechanical interlocks for increased safety. Customer specified components (i.e. instrument transformers, instruments, meters, and relays) are installed within this structure to complete a finished product that meets all applicable industry standards developed by ANSI, NEMA, and IEEE. This instruction bulletin should be used in conjunction with the appropriate PowlVac® vacuum circuit breaker instruction bulletins as well as any other components of the metal-clad switchgear.

B. Dimensions

The PowlVac-AR switchgear basic vertical sections are available in two configurations:

1) One-High Construction

The arc resistant switchgear consists of a single element in the vertical section lower compartment only.

2) Two-High Construction

The arc resistant switchgear consists of two elements in the vertical section lower and upper compartments.

*Note:* For certain configurations multiple auxiliary carriages may be located within an upper compartment allowing for three components to be housed in a single vertical section.

All configurations containing circuit breakers or auxiliary devices are 36” wide. The height and depth will vary depending on current ratings and equipment configuration. Standard dimensions are shown in Table A, Standard Dimensions. Variations to these standard dimensions may be available in specific circumstances.
Table A  Standard Dimensions

<table>
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<tr>
<th>Configuration</th>
<th>Continuous Current Rating (Amperes)</th>
<th>Internal Arcing Short-Circuit Rating (kA)</th>
<th>Height (inches)</th>
<th>Depth (inches)</th>
</tr>
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<td>1200, 2000</td>
<td>25, 36, 50, 63</td>
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Notes: 1. Height dimension does not include the plenum utilized on many designs. The plenum will raise the total height by 24 inches.
2. * FC is Forced Cooled

To maintain the arc resistant integrity of the design, access to primary components is limited by interlocks (See Ch 5 Operation) and operations such as racking the circuit breaker are restricted to methods where the compartment doors remain closed (See Ch 5 Operation, D. Racking Procedure Manual & E. Racking Procedure Electrical).

C. PRIMARY COMPARTMENT

The primary compartment contains the high voltage equipment and connections arranged in compartments to offer increased safety by minimizing personnel exposure and limiting the effects of faults. The primary compartment contains circuit breakers, control devices, current transformers, shutters, interlocks, and a ground bus.

D. SECONDARY COMPARTMENT

The secondary compartment or instrument compartment is located in the front of the equipment above the lower primary compartment (circuit breaker or auxiliary device). The compartment is provided with a hinged door for access to the low voltage control devices contained both on the compartment door and inside the compartment. Typically, control relays, indicator lights, and control switches are found on the door, while the terminal blocks, fuse blocks, and control devices are mounted inside the compartment. To accomplish interconnect wiring, multiple openings are provided between the adjacent secondary compartments and also between the primary compartments located immediately below or above the secondary compartment.

A horizontal passage way is provided across the lower rear wall of the compartment with approximately 4” diameter openings provided between all secondary compartments to carry the control and instrumentation wiring between the compartments. Additional openings may also be provided when the equipment requires more complex wiring. There is a vertical passage between the secondary compartment and the lower primary compartment on the right side wall which joins a wire way located in the lower compartment and extends through the bottom of the gear. That same wire way extends horizontally to the center of the secondary compartment bottom and opens into the compartment at the rear wall. A similar design is used in upper circuit breaker and auxiliary compartments, running from the top center of the compartment into the wire way on the right side (Figure 9, d) and into the secondary compartment. See Ch 5 Operation, Q. Field Wiring and Cable Connections for details on wire installation using these features.
Figure 1  1200A, 2000A, & 4000A Forced Cooled Compartment Doors Front View

- a. Instrument Panel Cover
- b. Handle
- c. Viewing Window
- d. Racking Access Window
- e. View Window for Operations Counter
- f. Shutter Position Indicator
- g. Interlock Defeat Access
- h. Emergency Push To Trip Button
Figure 2  3000A Compartment Doors Front View
Figure 3  Two-High Configuration
Figure 4  Inside View of Upper Compartment Door - 1200A or 2000A

- a. View Window
- b. Racking Access Port
- c. Shutter Interlock Actuator
- d. Instrument Panel Cover
- e. Manual Trip Actuator

Figure 5  Inside View of Lower Compartment Door - 1200A, 2000A, & 4000A Forced Cooled

- a. Instrument Panel Cover
- b. View Window
- c. Racking Access Port
- d. Shutter Interlock Actuator
- e. View Window for Operation Counter
- f. Manual Trip Actuator
Figure 6   Inside View Circuit Breaker Compartment Door 3000A

- a. Instrument Panel Cover
- b. View Window
- c. Racking Access Port
- d. Shutter Interlock Actuator
- e. 3000A Venting Assembly
- f. Manual Trip Actuator
Figure 7  Inside of Circuit Breaker Compartment

- a. Secondary Disconnect Plug
- b. Shutters
- c. Control Cable Entry Cover
- d. Circuit Breaker Ground Bus
- e. Interference Plate
- f. Emergency Push To Trip Actuator
**Figure 8**  *Inside of Circuit Breaker Compartment - Left Side*

- **a.** Compartment Light
- **b.** Mechanism Operated Cell (MOC) Switch
- **c.** Shutter Actuator
- **d.** MOC Actuator
Figure 9  Inside of Circuit Breaker Compartment - Right Side

a. Secondary Disconnect Terminal Board
b. Truck Operated Cell (TOC) Switch
c. Shutter Actuator
d. Control Cable Wire Way
e. Space Heater
f. Shutter Position Interlock
g. Control Cable Floor Entry Access
Figure 10  Two-High with Circuit Breaker in Connected Position
E. **Doors**

All doors covering access to the primary circuit components are constructed with arc resistant features. These doors must remain closed when the equipment is energized to maintain the assigned Internal Arcing Accessibility Type shown on the equipment nameplate. These doors vary in size and construction based on fault rating and function. View windows are provided on all front doors.

1) **Circuit Breaker Compartment Doors**

The doors are single step latching; closing the door and rotating the handle to the latched position provides the required compartment integrity to meet the internal arc fault rating assigned. No additional operations or specialized tools are required to operate the door. The door is fitted with panels to allow a limited number of control devices (circuit breaker operation switch, indicator lights, and test points) as may be required by the control scheme and the optional Sentry™ module.

The doors used for 3000A circuit breaker compartments are ventilated with a special louver system (Figure 6, e) capable of sealing in the event of an arcing fault. It is imperative that the vent system used on these doors be properly protected and maintained. External dust filters cannot be used on this design.

All circuit breaker compartment doors are equipped with interlocks to prevent misoperation. Details of these interlocks are described in *Ch 5 Operation* of this bulletin. The following interlocks are provided as standard equipment:

a. **Closed-Door Racking Interlock** - prevents racking the circuit breaker with the compartment door open

b. **Safety Shutter/Door Interlock** - prevents opening the compartment door if the safety shutters are not closed. Visual indication on front of the compartment door.

These two interlocks are interconnected such that a pad lock or other locking means may be used to block breaker insertion into the compartment.

2) **Auxiliary Device Compartment Doors**

The latching components are similar to the circuit breaker compartment door and while different in design, the operational interlocks provide the same door position/equipment condition functions.

3) **Rear Doors**

Rear doors may be full height or split (two doors) based on device isolation requirements in the rear compartments. Doors rated 50kA and below operate from a single handle with latching that is similar to the front doors. Doors rated 63kA are similar to the 50kA in design except they require additional tie-down bolts to withstand the additional pressure of a 63kA fault. These are standard 3/8” tie-down bolts and require a standard 9/16” wrench or socket to tighten to approximately 20-30 ft-lbs.
## Table B Ratings of Medium Voltage PowlVac-AR® Circuit Breakers

### 5kV

<table>
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<tr>
<th>Breaker Type</th>
<th>Cell Width</th>
<th>Maximum Voltage</th>
<th>Nominal Voltage</th>
<th>Symmetrical Interrupting Rating (kA rms)</th>
<th>Obsolete MVA Rating</th>
<th>Continuous Current (A rms)</th>
<th>Power Frequency Withstand (kV)</th>
<th>BIL Crest (kV)</th>
<th>Momentary Close &amp; Latch Rating (kA Crest)</th>
<th>%DC Interrupting Current (%)</th>
<th>Rated Interrupting Time (cycle/msec)</th>
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<th>Back to Back Capacitor Switching (Amps)</th>
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<th>Continuous Current (A rms)</th>
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<th>BIL Crest (kV)</th>
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Figure 11  Rear Door with View Window

a. Handle
b. Rear Door Interlock Defeat Access (optional)

F. Ratings

Ratings of PowlVac-AR® switchgear and circuit breakers are based on the following standards:

- ANSI/IEEE C37.04 Circuit Breaker Rating Structure
- ANSI/IEEE C37.06 Circuit Breaker Ratings
- ANSI/IEEE C37.20.2 Switchgear Assemblies
- ANSI/IEEE C37.20.7 Guide for Testing Metal-Enclosed Switchgear Rated up to 38kV for Internal Arcing Faults

See Table B, Ratings of Medium Voltage PowlVac-AR® Circuit Breakers for circuit breaker ratings.

Unless otherwise specified, the Rated Internal Arcing Short-Circuit Current for the switchgear is equal to the Symmetrical Short-Circuit Rating of the circuit breaker. Refer to the equipment nameplate for other rating information.

Application of PowlVac-AR under service conditions not considered “usual” may require derating or special construction.

G. Basic Impulse Level (BIL)

The basic impulse level is 60kV for 5kV class switchgear and 95kV for 15kV class switchgear.

```
Table C  Factory Dielectric Test Values

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H. Circuit Breakers

PowlVac-AR® switchgear is designed to house the many different types of components required to distribute and control electricity. The primary component in this distribution system is the circuit breaker. The PowlVac® circuit breaker is a vacuum type circuit breaker. It is designed to meet all the requirements for use in metal-clad switchgear and as such it has all the necessary interlocks and grounding to interface with the switchgear. It is a removable device, designed with wheels that make insertion and removal from the compartment a simple operation. All circuit breakers of the same breaker type and equal ratings are interchangeable.

For a detailed description of the circuit breaker and its operation refer to the appropriate instruction bulletin for the PowlVac vacuum circuit breaker.
I. **Safety Interlocks and Provisions**

1) **Key Interlocks**

Key interlocks are often supplied in conjunction with disconnecting switches, removable elements, and special compartments where access is dependent on other actions. The operation of key interlock schemes is generally described by a note or key chart on the work order drawings.

2) **Circuit Breaker Compartment Safety Provisions**

The PowlVac circuit breaker is equipped with a positive mechanical interlock that prevents moving the breaker unless the primary contacts are open. To rack the circuit breaker in any direction, the circuit breaker must first be opened. The interlock then interfaces with an actuator located in the circuit breaker compartment of the switchgear to hold the circuit breaker in a “trip-free” condition while the circuit breaker is being racked into or out of the connected position.

Safety shutters open and close over the stationary primary disconnect devices in response to the movement of the circuit breaker racking mechanism. A spring discharge interlock is provided to discharge the main closing spring when a circuit breaker is inserted into or withdrawn from the compartment. This interlock is activated by unplugging the secondary disconnect plug or the disconnect override device accessory.

A circuit breaker compartment interference plate is provided which is designed to hinder the insertion of an incorrect type or rating circuit breaker into the compartment. The breaker enclosure interference plates for the metal-clad switchgear and the circuit breaker are designed to allow a circuit breaker with equal or higher voltage and current ratings to be inserted in the compartment and to hinder insertion of a circuit breaker of a lower rating.

---

**NOTICE**

_Warning and Caution labels are located in various places. Do not remove or deface any of these warning/caution labels._

Before placing the equipment with key interlocks into operation, the key scheme must be carefully checked and only proper keys left in the locks.

All extra keys must be removed and discarded or secured where they are accessible only in an emergency.
The circuit breaker rating should always be checked against the rating of the metal-clad switchgear. Under no circumstances should the interference plate be removed from the circuit breaker or the switchgear as this action may allow the installation of a circuit breaker not rated for the compartment.

**WARNING**

Always verify the ratings and control scheme of a removable element before inserting into the equipment. Inserting an incorrectly rated element could result in death or serious injury.

A rollout stop block is provided to deter the removal of the circuit breaker from the compartment until the rollout latch on the circuit breaker is depressed.

### J. Circuit Breaker Racking Mechanism

The circuit breaker may be placed in three distinct positions within the circuit breaker compartment of the switchgear:

- Disconnected Position
- Test Position
- Connected Position

In the “disconnected position” the movable primary disconnects of the circuit breaker are disengaged and separated at a safe distance from the stationary primary disconnecting devices located in the compartment. A metal shutter covers the openings of the stationary primary disconnecting devices which prevents contact. In this position, the secondary disconnect devices and control contacts are disengaged.

In the “test position”, the primary disconnecting devices are disengaged and the shutters are closed. The secondary circuits are completed by inserting the secondary disconnect plug (switchgear) into the secondary disconnect receptacle of the circuit breaker. Now the circuit breaker may be electrically operated without affecting the primary circuit.

**Note:** At this time the circuit breaker is in the same physical location as the “disconnected position”.

In the “connected position”, the movable primary disconnecting circuits and stationary primary disconnecting circuits are engaged. The shutters are open and the secondary circuits and control contacts are completed.

Interlocks deter the movement of a circuit breaker from one position to another unless the circuit breaker is tripped open. The interlocks also deter closing the breaker between positions.

For CDR and ARM circuit breakers the secondary disconnect plug is an umbilical cord device. This multi-pin plug is located at the end of a cord attached to the top of the compartment. In order to rack the breaker into the compartment this plug must be inserted in the secondary disconnect receptacle. Once the plug is inserted and the breaker is racked past the “test position”, the plug is held captive and cannot be removed from the breaker.

For CDA circuit breakers the mechanism for connection of the secondary disconnect is found on the circuit breaker. Refer to the PowlVac® CDA circuit breaker instruction bulletin for more information.
For complete instructions on inserting and withdrawing the circuit breaker in and out of the switchgear, see Ch 5 Operation of this bulletin and also refer to the applicable PowlVac® circuit breaker instruction bulletin.

**CAUTION**

*If the control circuits are energized, the spring charging motor will operate to charge the circuit breaker's main closing spring as soon as the secondary disconnect plug is inserted into the secondary disconnect receptacle.*

**CAUTION**

*If the circuit breaker main closing spring is charged, withdrawing the secondary disconnect plug will cause this main closing spring to discharge.*

K. **Auxiliary Compartments**

Many sizes of auxiliary compartments are furnished in PowlVac switchgear lineups. A few are stated below:

- Bus transitions to motor controllers
- Bus transitions to transformers
- Cable entrance compartments
- Starting reactor or autotransformer compartments
- Relay and metering compartments
- Instrument transformer compartments
- Control power transformer compartments

These auxiliary compartments contain the same arc resistant features as the PowlVac-AR® switchgear and will have pressure relief venting on the top and reinforced panels and bracing on any compartment that contains a primary circuit component (such as a bus transition or incoming line). Additionally, auxiliary compartments may be used as fault gas vent areas for two-high designs. In this case, a special vent chimney will be configured inside the auxiliary compartment to provide fault pressure relief for adjacent compartments or vertical sections.

**CAUTION**

*The equipment that is adjacent to the arc resistant switchgear and connected through the transition may not be of an arc resistant design. Appropriate personal protective equipment (PPE) may be required to approach any adjacent equipment.*

L. **Anti-Condensation Heaters**

Anti-condensation heaters are provided in all PowlVac-AR switchgear in order to facilitate drying and prevent condensation. It is recommended that heaters are energized at all times; accordingly, no switch or thermostat is provided in the heater circuit unless specified. Each one-high basic construction is furnished with a heater providing 125 watts of heat. Each two-high basic construction has two such heaters, for a total of 250 watts of heat.

Heaters in circuit breaker compartments are located at the rear of the secondary compartment, below the lower primary disconnect devices. Heaters in auxiliary compartments are located in a similar location. In auxiliary compartments equipped with rollouts, it may be necessary to remove the lower rollout to gain access to the heater.

**Note:** Heater elements may also be located inside the plenum or exhaust duct to prevent condensation in these areas.
M. Auxiliary Devices

Auxiliary compartments use a closed-door racking device to move the auxiliary carriage to and from the connected position.

**WARNING**

Certain operations for the auxiliary device require that the compartment door be opened while the device is energized.

Opening the auxiliary compartment door while the equipment is energized exposes the operator to potentially lethal conditions by removing the arc resistant protection during the time the door is open and unlatched. The operator must wear the appropriate PPE for the level of flash hazard exposure indicated by the short-circuit rating of the equipment.

1) Voltage (Potential) Transformer

The voltage transformers are mounted on a rollout carriage equipped with primary and secondary disconnecting devices. When the voltage transformers are disconnected, they are at a safe electrical distance from all live parts of the switchgear. In addition, a grounding device is provided which contacts the fuses when the voltage transformers are disconnected, effectively discharging the transformers. In this position, the transformer fuses may be safely removed and replaced. When the voltage transformer rollout tray is in the disconnected position, the rear barrier of the carriage effectively deters access to the stationary primary disconnect devices mounted in the compartment behind the rollout tray. However, these stationary primary disconnect devices may remain energized.

**WARNING**

Do not remove the rollout tray from its rails without first deenergizing the primary circuit to which the rollout connects. Removing the tray makes the stationary primary disconnect devices accessible.

2) Fuse Disconnecting Device

The primary disconnecting devices mounted on the rollout carriage are capable of interrupting transformer magnetizing current, but should not be used to interrupt load current. Mechanical or key interlocks are applied to prevent disconnecting the control power transformer, by withdrawing the rollout carriage while the transformer's load is connected. This is generally accomplished by interlocking so that the transformer secondary circuit breaker must be locked in the open position before the disconnecting device can be moved.

When the fuse or control power transformer rollout carriage is in the disconnected position, the rear barrier of the carriage effectively deters access to the stationary primary disconnect devices mounted in the compartment behind the rollout carriage. These stationary primary disconnect devices may remain energized.

**WARNING**

Do not remove the rollout tray from its rails without first deenergizing the primary circuit to which the rollout connects. Removing the tray makes the stationary primary disconnect devices accessible.
3) Current Transformers (Window-Type)

Window-type current transformers are positioned around the stationary primary disconnect devices. They are removable from the front and may be located on upper and/or lower primary disconnect supports. If necessary, special current transformers may be mounted in the cable compartment.

**WARNING**

Prior to servicing or removing current transformers, deenergize the associated primary circuits.

O. Primary Disconnect Devices and Supports

Prior to adjustments, servicing, maintenance, or any act requiring the operator to make physical contact with the equipment, the power source must be disconnected and the equipment grounded. Failure to do so may result in death or serious injury.

The stationary primary disconnect devices are flat silver-plated copper contact bars located within the molded epoxy supports found at the rear of the circuit breaker compartment, behind the safety shutters. The rear of the contact is bolted to the main bus riser or to the line-side bus. The contacts may be withdrawn from the rear of the supports when other bus connections have been removed.

The movable primary disconnect devices (on the circuit breaker) will engage automatically with the stationary primary disconnect devices near the end of the racking cycle. Contact penetration is set by the racking device and no additional adjustments should be necessary. The removable element disconnect contacts are self-aligning fingers, which will compensate for minor misalignment of up to approximately 1/8 inches.

N. Main Bus, Main Bus Taps, and Grounds

The main bus, main bus taps, and ground bus conductors are made of copper. The bolted connections are silver-plated or tin-plated. The main bus, main bus joints, and taps are insulated. This insulation provides protection against the propagation of arcing ground faults, but does not offer personnel protection against shock hazards.

The main bus supports of a 15kV class metal-clad switchgear lineup are of molded epoxy. The main bus supports of a 5kV class metal-clad switchgear lineup are of glass polyester laminate.

P. Lighting

Closed-door racking switchgear is equipped with a 120VAC interior light (Figure 8, a) and a door mounted light switch. When the interior light is switched on in the circuit breaker compartment, the user can read "breaker test/disconnected" or "breaker connected" on the circuit breaker position indicator through the view window.
Ch 4 Installation

Contact the Powell Service Division for installation, maintenance, and renewal parts assistance. To contact the Powell Service Division call 1.800.480.7273 or 713.944.6900, or e-mail info@powellservice.com.

It is the responsibility of the purchaser to set or program components such as protective relays, meters, timers, etc., in accordance with the requirements of the particular installation, before placing the switchgear with vacuum circuit breakers into service. Programmable devices may be shipped with temporary programming, used to test the switchgear. Electromechanical relays may be shipped in a blocked position to avoid damage during shipment. Refer to separate instructions for these components for information on setting or programming.

A. General

This section contains information on receiving, handling, positioning, power cable termination, grounding, and checks to make the equipment ready for operation.

Once the assembly of the switchgear is completed on site, all joints and hardware, including bus connections, structural assemblies, and control connections, should be checked for tightness and proper torque values.

B. Receiving

PowlVac-AR® switchgear is fabricated in rigid, floor-mounted, self-supporting steel vertical sections. Indoor shipping assemblies are enclosed in a covering to protect the switchgear lineup from the weather. The switchgear vertical sections are shipped in an upright position, and when received should be kept upright.

When the switchgear lineup reaches its destination, the purchaser should check the material actually received against the shipping list to be sure that all parts have been received. If damage is found or suspected, file a claim as soon as possible with the transportation company and notify the nearest Powell representative.

The removable elements such as the circuit breaker may be shipped separately. Refer to the instruction bulletin furnished for receiving, storage, and handling instructions on the circuit breaker.

Some other components, such as top-mounted resistors or potential transformers, may also be shipped separately. These components are identified by a number coinciding with that of the switchgear vertical section on which they are to be mounted.

C. Handling

If the switchgear is provided in a PCR®, refer to the handling instructions contained in the instruction bulletin for the PCR.

It is always preferable to handle a PowlVac-AR switchgear lineup with an overhead crane and the lifting means provided on the switchgear. Because of the weight of the arc resistant equipment and the critical tolerances required to provide the necessary seal for fault protection, it may be necessary to separate the shipping split into single vertical sections. This will increase the maneuverability and reduce the chances for damage while moving the switchgear.
1) **Lifting the Switchgear**

PowlVac-AR® Switchgear is provided with lifting angles on the front and rear of the equipment. The typical shipping split of two vertical sections will share a common lifting angle. This angle is approximately 72” long. Single vertical sections will use a lifting angle approximately 36” long. Use the lifting angles provided. Do not substitute any other device for this operation. Do not replace the hardware provided with any other grade.

The lifting angles should be bolted to each switchgear section in two places:

a. The front angle should be across the back edge of the front compartment or approximately 20” from the front of the switchgear. This location may be in the back of the instrument compartment on a one-high design. When this is the case, a support brace is located between the back of the instrument compartment and the front of the main bus compartment. This brace must be in place or damage to the switchgear will occur.

b. The rear angle should be across the back of the rear cell (not the door frame).

c. In both cases, the vertical portion of the angle should be facing the center of the vertical section.

d. The angles should be bolted with ½” - 13 hardware (minimum grade 5) including a large flat washer and split lock washer, in the corner of the section.

e. The bolt should mate with a ½” - 13 nut, welded on the inside of the switchgear.
f. The lifting angles must sit flat on the top of the switchgear. In some cases, an access plate on the top of the instrument compartment may interfere with the lifting angle and prevent it from sitting flat on the top surface. When this occurs, remove the access plate until the equipment is set in place.

Because the equipment is custom built for the application, the size, weight, and center of gravity will vary. Always refer to any handling instructions specific to the job. As a general rule, the equipment is typically heavier in the rear because of the bus work. The chains or straps used to lift the equipment should be adjusted to minimize tilting when lifting. This will make placing the equipment on the floor or on other transport equipment much easier.

The equipment is normally shipped with the plenum assembly removed to reduce the shipping height. It is preferred that the plenum remain off until all handling with an overhead lifting device is complete. Should it be necessary to have the plenum installed prior to using an overhead lifting device, a spreader bar must be used to prevent the chains or straps from the lift from damaging the plenum and the front lifting angle must be installed at the front of the top compartment.

2) **Moving the Switchgear**

The preferred method for moving the switchgear when it is not possible to use a crane to set the switchgear in place is with the use of rollers or heavy-duty, thick walled type pipe. Larger diameters will make movement easier.

a. If pipe is used, it must extend past the edges of the switchgear on both sides.
b. If rollers are used, they must be placed on the corners of the equipment.

The use of a forklift truck to slide under the switchgear is not recommended on the switchgear, however if no other method for handling is available, it is possible to move the equipment with this method. Caution must be exercised to avoid deforming the switchgear frame due to uneven weight distribution when lifting with a forklift.

1. It is recommended that only one section be moved at a time.
2. The forks must go directly under the bottom base at the side walls to avoid damage to the switchgear.
3. The forks should extend completely under the equipment.

---

**CAUTION**

*Under no circumstance should a forklift be used to raise a corner or portion of the switchgear to position the equipment or lift it over conduit or other obstructions on the floor. Such action may distort the switchgear frame and cause latches to fail or create misalignments that could impact the arc resistant integrity.*
D. Storage

Shipping and storage of electrical equipment requires measures to prevent the deterioration of the apparatus over a long unused period. The mechanical and dielectric integrity must be protected. Electrical equipment is designed for use in a variety of environments. When the equipment is in transit and storage, these design considerations are not fully functional. In general, the following measures must be considered.

1. Equipment designed for indoor installation must be stored indoors in a climate controlled environment to prevent condensation of moisture. Exposure to rain and the elements, even for a short period, can permanently damage the equipment. Space heaters within the equipment should be energized. Humidity controlling desiccant materials should be utilized when space heaters are not provided or cannot be energized. The temperature should be kept above 33°F/1°C and below 140°F/60°C. The relative humidity should be kept below 60% or a dew point of 15°C/59°F. The equipment should be stored in such a manner as to leave all doors and panels accessible for inspection. The equipment must be inspected on a routine basis to assure operational integrity.

2. Equipment designed for outdoor exposure may be stored either in indoor or outdoor storage locations. The equipment must be protected from airborne external contaminates if stored outdoors. Outdoor storage will also require additional care to maintain temporary covers over the openings and shipping splits. The equipment must be provided with control power to facilitate the energization of space heaters, as well as other temperature and humidity controlling equipment. The temperature should be kept above freezing (>33°F/1°C) and below (<140°F/60°C). The relative humidity should be kept below 60% or a dew point of 15°C/59°F. The equipment should be stored in such a manner as to leave all doors and panels accessible for inspection. The equipment must be inspected on a routine basis to assure its integrity.

3. The auxiliary control devices, ship loose material and protective relays must also be protected. This includes items such as battery chargers, UPS systems, lighting, installation hardware and air conditioning. If prolonged storage is anticipated, humidity controlling desiccant materials should be utilized. Desiccant packets should be installed in all compartments and packing containers.
E. Preparation of Floor Anchoring

The station floor must be strong enough to prevent sagging due to the weight of the switchgear structure and to withstand the impact stress caused by the opening of the circuit breakers under short-circuit conditions. The impact loading is approximately 1½ times the static load.

It is essential that the floor be level to avoid distortion of the switchgear structure, and that the switchgear be completely aligned prior to final anchoring. This is accomplished by using floor leveling channels. The leveling channels should have a minimum web dimension of 4 inches. The required quantity and locations of the leveling channels and the spacing of the leveling channels, including the center channel, is shown on the drawings furnished with the order. Figure 13 shows the recommended orientation for the channels to be placed in the floor. The floor channels must be level and straight with respect to each other. The exposed top surface of the leveling channels must be flat and form a level surface plane for the entire switchgear assembly to rest upon. The surface plane of the leveling channels should be flat within ¼” (the two planes defined by the highest point and lowest point of the leveling channels must be within ¼”). The overall floor slope should not exceed ⅛” across the front-to-back or end-to-end dimension of the switchgear lineup. In no case may the concrete floor rise above the level of the floor leveling channels.

Care should be taken to provide a smooth, hard, and level floor surface in front of the units to facilitate installation and removal of the circuit breakers. The floor in front of the circuit breaker compartments should be level with, or slightly below, the base of the switchgear to facilitate inserting and withdrawing the circuit breakers. The step up from the floor into the circuit breaker compartment is no more than the two metal thicknesses that make up the compartment floor and breaker pan (less than ¼”). Critical components on the circuit breaker may be damaged if the step is larger. Should there be a gap between the concrete floor and the top of the floor leveling channel at the front of the lineup, the floor must be leveled relative to the circuit breaker compartments for approximately 36” extending away from the switchgear. This will assure the circuit breaker enters its compartment with a step up of no more than ¼”.

When installing the switchgear on existing floors, it is recommended to pour a new finish floor with embedded channels, or to cut slots in the floor for embedding and leveling the supporting channels.

Encircling loops of reinforcing or building steel around single-phase conductors should be avoided in the areas for main cables when these circuits are rated at 600 amperes or above.
The user must provide suitable means for anchoring the switchgear to the floor. Recommended practice for anchoring the switchgear to the floor is to weld the switchgear structure to the floor channels using a tack weld at points indicated for anchoring on the drawing. After welding, any damaged paint should be removed and the weld and surrounding metal painted to deter corrosion. If welding facilities are not available, the switchgear should be bolted to the floor channels. The switchgear must be in full contact with the leveling channel at the point of bolting to avoid distortion when tightening the hardware.

Provision should be made in the floor for conduits for primary and secondary cables, located as shown on the floor plan drawing furnished for the particular order. If desired, the conduits may be installed before the switchgear. Positioning rollers, if used, should be high enough to allow the switchgear to pass over any conduits that might be required for future connections.

After all the equipment is located and fully installed, examine the bottom edge of the switchgear at the floor for gaps. Any gap greater than \( \frac{1}{8} \)” between the concrete floor and the switchgear must be filled. Silicone RTV is suitable for filling gaps \( \frac{1}{4} \)” or less. For gaps greater than \( \frac{1}{4} \)” it is recommended that concrete or mortar be used. Failure to fill these gaps may result in hazardous gas escape from under the switchgear in the event of an internal arcing fault.
Figure 12  Installation of End Cover Panels

a. Ceiling of PCR®
b. Plenum
c. Plenum Access Point (shown with cover plate removed)
d. End Cover Panels
e. Cover Panel Hardware
F. Positioning the Metal-Clad Switchgear

1) General

The recommended aisle space at the front and at the rear of the switchgear is shown on the floor plan drawing furnished for the particular order. The space at the front must be sufficient to permit insertion, withdrawal, and transferring of circuit breakers. The space at the rear must be sufficient for installation of cables, for inspection and maintenance, and on some switchgear to rollout voltage or control power transformers. The dimensions shown on the switchgear drawings are those required for proper operation of the switchgear. The space at the ends of the lineup can affect the function of the switchgear. There must be 36 inches from the right end (operator’s left while facing the switchgear) of the lineup to the wall or adjacent equipment to fully open the circuit breaker compartment door. When the equipment uses upper breakers (two-high construction) a minimum aisle way of 6 feet is necessary to allow maneuvering of the lifting truck.

Applicable national or local codes or regulations may require greater aisle space than is needed for operation of the switchgear. It is the purchaser’s responsibility to comply with these codes and regulations.

When three or more switchgear units are to be arranged in one continuous lineup, the center shipping unit should be located first. The other shipping lineups should then be installed in successive order in each direction from the center of the structure.

When installing a unit substation or power center, the power transformer and the adjacent switchgear lineup should first be lined up and set in position in accordance with the dimensions on the base plan drawing for the installation. The additional units should then be installed.

Additional shipping supports may be installed in the bus or primary area to ensure against shipping damage. It is imperative that all shipping supports are removed, and joints properly tightened and insulated before energizing the bus.

Mats, screens, railings, etc., which are external to the switchgear and may be required to meet any local codes, must be furnished by the purchaser. Be sure to discuss these items with the manufacturer prior to installation as they may affect the performance of the switchgear.
Figure 14  Vent Duct Assembly

Typical installations of duct are less than 10ft. The duct overlaps the plenum collar by approximately 8" allowing for adjustment of penetration into the exhaust vent (wall side) to the point where it stops.

Notes:
1. All dimensions are approximate. Exact dimensions are provided with the job drawing package.
2. The wall cutout is 24H x 34W
3. The wall cutout should be located lower than the corresponding switchgear side of the duct to prevent condensation ingress into the equipment.
   a. For a duct length of 5 feet or less, set the centerline of the wall cutout 0.5" below that of the centerline height of the plenum exit.
   b. For a duct length of greater than 5 feet, set the centerline of the wall cutout 1" below that of the centerline height of the plenum exit.
4. The centerline for the duct at the switchgear plenum exit is 116" for 105" high switchgear.
5. The centerline of the duct at the switchgear plenum exit is 106" for 95" high switchgear.

Parts List

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>Arc vent collar</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Internal mounting frame</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Mounting strip</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Hood</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Arc duct tie down angle</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>Arc duct plenum side</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
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</tr>
<tr>
<td>1</td>
<td>8</td>
<td>Plenum exit</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>Vent cover</td>
</tr>
</tbody>
</table>

Customer building wall is between 3" and 6" thick
2) **Assembly of Shipping Splits**

Much of the arc resistant functions come from proper assembly of the switchgear. The procedures for free-standing equipment and PCR® installed equipment are slightly different. When reassembling the shipping splits use the following guidelines:

a. **Free-Standing Switchgear (Customer Building)**

Refer to this section and *Ch 4 Installation, C. Handling* for instructions on moving the equipment into position.

Once in position, final alignment is based on the hardware locations shown in Figure 15. There are four (4) vertical rows of hardware to connect each vertical section to the adjacent section. Note that the front and rear rows are assembled with full hardware sets (nuts, bolts, and washers). The two center locations may utilize either hardware sets or captive nuts in one section. Insert hardware in all holes and tighten to specification. Figure 15 shows a typical lineup of ≤ 50kA equipment. 63kA equipment will have additional hardware points in the 4 rows shown and across the tip of the circuit breaker compartment.

b. **Switchgear Inside a Power Control Room**

Generally, the equipment provided in a PCR is located in its proper place and fully assembled except for the sections on the shipping split. There is often a transition compartment provided at the split to serve as an easily accessible point to connect the bus or to clear the wall and ceiling beams of the PCR.

Remove the main bus access covers in the rear compartment to gain access to the center set of mounting hardware holes. These covers should remain off until after the bus is installed. See *Ch 4 Installation, F. Positioning the Metal-Clad Switchgear, 1) General* and *Figures 17 & 18* for information on aligning the switchgear.

i. **Assembly Without a Transition**

The adjacent sections of switchgear are already attached to the floor (and the rear wall for wall-mounted gear). With the building components correctly aligned, the switchgear should also be aligned. From inside one of the two sections, locate the attachment points between the adjacent vertical sections of switchgear. There are four (4) vertical rows of hardware to connect each vertical section to the adjacent section. See Figure 15 for locations. Note that the front and rear rows are assembled with full hardware sets (nuts, bolts, and washers). The two center locations may utilize either hardware sets or captive nuts in one section. Insert hardware in all holes and tighten to specification. Figure 15 shows a typical lineup of ≤ 50kA equipment.
63kA equipment will have additional hardware points in the 4 rows shown and across the tip of the circuit breaker compartment.

ii. Assembly With a Transition

The adjacent sections of switchgear are already attached to the floor (and the rear wall for wall-mounted gear). The shipping split transition is typically 24” wide and is designed with slotted holes in the barriers to expand or contract to accommodate fluctuations in equipment size and alignment.

Prior to reassembly of the PCR®, determine if the transition components are attached to the adjacent section of switchgear and if there are any components (such as bus bar and transition plenum components) that should be placed in the equipment prior to reassembly to facilitate the process. The transition components mount to the switchgear at the same points shown in Figure 15. Assemble the transition components to the two facing sides of the switchgear. The main bus cut-out on each adjacent switchgear section is fitted with a collar that the bus barriers are installed to after the shipping split is assembled.

With the building components correctly aligned, the switchgear should also be aligned.

To assemble the transition attach the inside main bus barrier assembly. Then attach the top assembly followed by the front and rear assemblies.

c. Bus Assembly

i. Follow the recommended torque instructions found on labels inside the rear compartment.

ii. Cover bus joints with appropriate boot or other insulating material provided.

iii. Connect the ground bus located in the bottom rear of the cable compartment.

3) Plenum Assembly

The preferred method of controlling the by-products of an internal arcing fault is to channel these gases out of the room where the gear is located. This task is accomplished by use of a plenum located above the switchgear and venting ducts which carry the gases from the plenum to a desired location.

In site erected buildings it may be desirable to contain the arc fault by-products within the building. This arrangement would have been discussed during the equipment design and the building requirements provided as part of the negotiation. A shroud plenum designed with louvres in some or all sections will be provided and there will be no exhaust duct assembly or external building vent.

⚠️ WARNING

It is critical to the performance of the switchgear protective scheme that the plenum and ducting be properly assembled and supported. Failure to follow the assembly instructions may result in the release of arc fault by-products at undesired locations or compromise the performance of the switchgear barrier system.
a. Plenum and Barrier Assemblies

Every installation is examined for suitability of a specific plenum design as part of the engineering design process. The size of the plenum, the number and location of the venting ducts and the length of the vent ducts are determined by type testing and engineering evaluation.

The following types of plenum and barrier constructions are offered, based on the application and room design:

i. For the Powell PCR® - A plenum made from barrier plates mounted around the perimeter of the equipment and tied directly to the building's ceiling or a plenum made from modular shrouds that cover the top of one or two vertical sections for the lineup and are tied together to create an assembly. The ends are sealed to protect the adjacent aisle ways.

ii. For Customer Buildings - A plenum made from modular shrouds that cover the top of one or two vertical sections for the lineup and are tied together to create an assembly. The ends are sealed to protect the adjacent aisle ways.

b. Assembly of Plenum or Barrier in a PCR®

Reassembly of the equipment, including the plenum, is required at the PCR shipping split for all equipment crossed by the split. The components for the shipping split transition plenum assembly will be shipped as a separate item.

i. Barrier Assembly - Connect the front vertical barriers (and rear if the switchgear is not mounted against an outside wall) using the hardware provided and attach the barrier to the PCR ceiling.

ii. Modular Shroud - Typically, a transition is used to span the shipping split. The transition is designed to expand or contract to accommodate variations in manufacturing tolerances and the reassembly process. The plenum is also designed to expand or contract to fit the open space between the adjacent switchgear sections. Once the transition components are reassembled, the plenum components may be installed.

- Attach the left and right side components to the respective switchgear plenums and install the covering piece(s).
- Attach the plenum components across the front and rear to the top of the transition assembly using the hardware provided.

⚠️ CAUTION ⚠️

Designs that allow venting into the equipment room have been evaluated for the flash hazard only. These designs meet the requirements of arc fault testing, but provide no mitigation for by-products such as smoke and sound pressure. The user should evaluate those risks.
Figure 15  Side View of Typical Shipping Split

a. Four Rows of Hardware
Figure 16   Front View of Typical Shipping Split
Figure 17  Rear Compartment Shipping Split Assembly
Figure 18   Bus Installation
c. Assembly of Plenum in an Open Building

For installation in a customer building, PowlVac-AR® is typically split into two vertical sections. The plenum may be attached to the switchgear during shipment. If the plenum is attached to the switchgear the following precautions must be taken when handling the equipment:

i. If the equipment is to be lifted via overhead crane, a spreader bar must be used to avoid damaging the plenum.
ii. The path to the installation location must be evaluated for adequate overhead clearance.
iii. The equipment must never be lifted by the plenum. The plenum is not designed or attached to the equipment in a manner capable of supporting the equipment weight.

If the plenum shrouds are shipped separately:

i. Attach the plenum to the top of the switchgear using the sets of holes at the back of the instrument compartment and the middle of the cable compartment. Use the 3/8" captive nuts and ½" weld nuts provided.
ii. Connect the adjacent plenum components across the front, top, and rear using the hardware provided.

*Note:* One side is a round hole and the mating piece will be slotted to aid in alignment.

iii. The ends are sealed with plates that attach to the edge of the plenum to the top of the switchgear and across the side of the switchgear.
iv. This type of plenum may be provided with or without an exhaust duct. If there is sufficient clearance above the equipment, a louvered plenum may be provided to exhaust fault gases into the equipment room. Be certain during installation the louvered plenum(s) is located exactly where it is shown in the layout drawings for the job and that no obstructions are placed above the louvers to impede gas flow from the equipment.

When the arc fault by-products are to be vented into the building, the following additional steps and precautions are required:

i. Clear space above the louvered plenum sections is based on the available fault level.
   • For Arc Fault ratings of 50kA or less, the space above the plenum is required to be a minimum of 24 inches.
   • For Arc Fault ratings above 50kA, the space above the plenum is required to be a minimum of 48 inches.
ii. There can be no obstructions above a louvered plenum assembly. This includes light fixtures, cable trays, bus duct, HVAC duct, etc.
iii. Where such items cross the switchgear, arrange the plenum such that non-louvered plenum components are below the obstructions.
iv. In cases where all the plenum components are louvered or the room layout has changed, Powell can assist in designing barriers to prevent undesirable fault gas deflection.

**WARNING**

*Failure to provide adequate clearance above the louvered plenum section(s) can compromise the internal arcing fault accessibility type and possibly reflect hot gases capable of causing serious injury or death.*

4) **Exhaust Duct Installation**

All plenum assemblies require a method to vent the fault gases from the plenum to a designated area away from other equipment and personnel access; typically out of the room.

In a PCR® installation, the exhaust vent(s) are built into the walls of the PCR and all necessary precautions have been included in the design and installation.

When the exhaust duct is provided and field installation is required, the following rules apply:

- **a.** The duct must slope away from the equipment. A drop of 0.5 inches over a 5 foot length of duct is sufficient. For longer ducts, a drop of 1 inch over the total length is recommended.

- **b.** The duct must be adequately supported. Do not omit any of the provided mounting brackets. It is recommended by Powell to keep the duct length to less than 10 feet. In this case, the connection to the switchgear and wall proved the required support. Where longer ducts are necessary, support should be provided approximately every 10 feet, typically at the connection between sections. Standard duct weighs approximately 45lbs/linear foot.

- **c.** The exit point for the duct must be sealed to the building wall, weather-tight, and secured to the duct.
5) Access

All plenum assemblies will have an access point to facilitate initial assembly and maintenance. This access point is typically located in one of the panels along the front of the equipment, but may be located on an exposed end (if an end is exposed in the lineup). Figure 21 shows a typical access point with the cover panel partially open.

**WARNING**

Do not remove the cover of the plenum access point while the switchgear is energized.

It is critical to the performance of the switchgear protective scheme that the cover for the access point to the plenum be properly installed while the equipment is energized. Failure to install or properly secure this cover may result in the release of arc fault by-products at undesired locations or compromise the performance of the switchgear barrier system.

**WARNING**

Do not enter the plenum with any part of the equipment energized.

Doing so will expose the operator to the potentially lethal by-products of an internal arcing fault.

**WARNING**

Entering the plenum may expose the operator to hazardous voltages on incoming lines. Verify that the incoming lines are deenergized and grounded prior to working in the plenum.

6) Placement of Equipment Near Exhaust Ducts

When a plenum and ducting system is utilized to control the by-products of an arcing fault, several site considerations must be made with respect to where the gas will be vented. Because the gas release is at an elevated temperature and pressure and contains metallic particles and toxic components, the location of the vent must be isolated from personnel and sensitive equipment. Further, when the gas is vented into the building the structural capability of the building to withstand the overpressure and the effects of the smoke and toxic gas in a closed area must also be evaluated.

Due to the circuitous route the arc blast takes through the switchgear, the plenum, and the duct system, a large part of the fault energy is attenuated inside the switchgear system. There is still a significant amount of energy that leaves the exhaust port and, depending on the speed of the protective scheme, a significant level of toxic gas and smoke may be released.

Pressure measurement in the switchgear during testing reveals significant drops in value as the gas works its way to the exit point of the duct. A typical 63kA three phase fault in a circuit breaker compartment sees an average peak pressure in that compartment of 12psi. The pressure is reduced to approximately 2psi when it reaches the exhaust duct external cover. At this point the gas has traveled at least 8 feet and the drop in pressure reflects the loss of energy that occurs.

The gas temperature also drops exponentially as it moves from the source.
The temperature of the fault gases exiting the duct in the typical test sample are around 200°C and will continue to cool as it moves from the vent. The toxic nature of this gas does not decrease based on distance traveled and for that reason it is preferred to vent the gases outside of the building.

Additional precautions, beyond those concerned with the temperature of the gases, will be required when the gas is released in a confined space or building. These precautions include evaluation of the effect of an overpressure on the structure and the availability of light and fresh air.

The isolation area for the exhaust duct to vent into can be visualized as a 5 foot diameter cylinder around the center line of the exhaust duct that extends 7 feet out from the exhaust duct opening. While the actual flow of gas resembles an ellipsoid within the borders of the described cylinder and will vary in intensity based on fault current level and proximity to the vent opening, using the cylinder dimensions as the borders of the isolation area provides a simple and effective method to define the space. This space must be free of personnel, sensitive equipment, and physical impediments to gas flow when the equipment is energized.

**G. Door Alignment**

If for any reason it is necessary to realign the doors of the switchgear during installation, perform the following:

1. After checking that the switchgear is level and plumb as earlier described, start at either end of the switchgear lineup and realign each door individually as required.
2. The top of each door should be level with the adjacent doors; the sides of each door plumb; the surface of each door flush with adjacent doors; and the space between adjacent doors equalized to permit their free swing and present a neat appearance.
3. Door may be raised or lowered vertically, moved left or right horizontally, or rotated to plum them, by loosening the mounting screws which attach the door to the movable half of the hinge assembly. These screws are located on the inside of the door. The door assembly may then be adjusted as allowed by the holes in the door, which are slightly oversized.
Figure 20  Plenum Overview

Figure 21  Plenum End View

a. Access Cover (shown partially open)
4. **PCR® Rear Doors** - When properly aligned, the rear doors of the switchgear (exterior doors of the PCR) should be tightly seated on the gasket that surrounds the door opening. After aligning the door as described above, close and latch the door and check the seal by inspecting the gasket for compression.

5. Check alignment of door shutter position interlock. With the equipment deenergized and the circuit breaker removed, enter the breaker compartment and close the door until the shutter position interlock actuator on the door contacts the upper linkage on the interlock. Verify that there is proper engagement and that the actuator will not move enough to miss the linkage. Verify that with the door fully closed, the lower linkage of the interlock will operate the latch so that the safety shutters are free to move.

**H. The Removable Element**

The removable element may be shipped loose in its own protective box or inserted in the switchgear when the equipment is installed in a PCR. If the circuit breaker is shipped in the switchgear, it will be locked in place by a special bracket designed to prevent motion during shipment. This bracket (*Figure 22, a*) must be removed and discarded in order to move the circuit breaker. If the auxiliary device is shipped in the switchgear, it will be in the "Disconnected" position and the door will be locked with a tie-wrap or padlock (*Figure 23*).

*Before installing or operating a removable element, such as the circuit breaker, ground and test device, or dummy removable element, consult the instruction bulletin for directions on installation, maintenance, and renewal parts for that particular element.*
Removable elements located in the one-high construction, or in the lower compartment of the two-high construction may be rolled into the vertical section of the switchgear from the floor. Removable elements located in the upper compartments of two-high construction must be lifted into place using the optional lift truck or some other method of crane or hoist. The recommended lifting procedure is described in Ch 5 Operation.

For a detailed description of the circuit breaker and its operation, maintenance, and renewal parts, refer to the appropriate PowlVac® circuit breaker instruction bulletin.

See Ch 5 Operation for specific details on inserting the removable element into the compartment. Installation of the auxiliary devices is covered in Ch 4 Installation, R. Auxiliary Device Rollout Carriage.

I. **GROUNDING**

The switchgear assembly must be grounded before power connections are made.

External power connections should be installed after the equipment is placed in its permanent location and the grounding connections are completed. Temporary safety grounding cables must be connected to the equipment ground bus and all high voltage terminals that are handled or touched during power connection and installation.
It is recommended that the connection to the station ground have a cross section of 500,000 circular mils (240mm²) or greater if the soil in which it is buried is of such character as to cause appreciable corrosion. This is especially true where electrolysis from stray currents or contact with dissimilar metals exist. The resistance of the soil surrounding a station ground depends on the condition of the soil, as well as its chemical content. Dry, loose, sandy, or frozen soils will have a high resistance as compared with moist soils or soils containing ashes, cinders, or salt solution. The IEEE Standard 142 states that grounding impedance in the range of 1 to 5 ohms is generally acceptable for industrial substations. Ground resistance testing is recommended to verify that the ground resistance falls within this range.

J. Connections

The main bus bars and other connection bars are copper. The connection surfaces are silver surfaced or equivalent. The silver plating used on bolted contact surfaces is approximately 0.0001” thick. All field assembled joints in primary conductors, regardless of method of installation, should be made as follows:

1. Wipe the surface clean with a lint free cloth. Do not use sandpaper or any abrasive on the plated surface. Avoid handling of cleaned surface as much as possible. If the surface is tarnished, clean it with silver polish and then wash it with denatured alcohol.

2. Join the clean contact surfaces by using the hardware provided. The correct length of bolt must be used in each joint to ensure that electrical clearances at bolt locations are maintained. As a general rule, when using ½” diameter bolts, the bolt should be 1” longer than the combined thickness of the copper bars being bolted together. For example, if three ¼” thick copper bars are to be connected, the bolt should be 1¾” long. In addition to proper length bolts, the bolt assembly must include flat washers, split ring lock washers, and nuts. All hardware must be SAE Grade 5 or better. Refer to Figure 24 for proper assembly of hardware.

![Figure 24: Ground Bus Splice Plate Connection](image)

- a. Bolt
- b. Flat Washer
- c. Bus Bar
- d. Split Lock Washer
- e. Nut

CAUTION

All exposed primary bus and cable joints and connections should be insulated for the correct system insulation rating.

3. In some cases, external connections are made to the equipment main bus by bars. The equipment bars are normally silver-plated. Unplated bars either copper or aluminum should not be used to connect to plated bars.

4. All field assembled primary conductor joints and terminations must be insulated for the operating voltage. There are two methods of insulating the joints: Taping joints or applying boots where applicable. A detailed procedure for joint insulation is described in Ch 4 Installation.

Note: All hardware must be tightened to the torque values listed in Table D, Bolt Torque Values.
Table D Bolt Torque Values

<table>
<thead>
<tr>
<th>Bolt Dimensions (inches)</th>
<th>Bolt Head</th>
<th>Torque</th>
<th>Ft-Lbs</th>
<th>Kg-M</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td></td>
<td></td>
<td>55-70</td>
<td>7.6-9.7</td>
</tr>
<tr>
<td>1/2</td>
<td></td>
<td></td>
<td>35-50</td>
<td>4.8-6.9</td>
</tr>
<tr>
<td>3/8</td>
<td></td>
<td></td>
<td>20-30</td>
<td>2.8-4.2</td>
</tr>
<tr>
<td>1/4</td>
<td></td>
<td></td>
<td>5-7</td>
<td>0.7-0.97</td>
</tr>
</tbody>
</table>

Note: The bolt head drawings in the table above are not to scale. Locate the Bolting Torque label on the equipment of an accurate drawing of bolt sizes.

1) **Main Bus Assembly and Insulation**

The main bus is accessed through either the rear door of the switchgear or from inside the plenum area (through the breaker compartment). Open the rear door and remove the main bus compartment covers to access from inside the breaker compartment. Then open the pressure relief covers and remove the support brace across the top of the breaker compartment. Lastly, remove the vent covers on the main bus compartment to access the bus.

2) **Installing and Connecting Main Bus Conductors**

To insulate the main bus assembly, remove the rear compartment covers. Then bolt the splice plate and bus bars together, following the assembly instructions in *Ch 4 Installation, J. Connections*.

3) **Main Bus Joint Insulation**

Main bus joints are insulated with either a custom fitted boot or with hand applied insulating tape. *Ch 4 Installation, J. Connections* will describe the procedure for hand applied insulating tape wrapped joints. After installing main bus conductors as described in *Ch 4 Installation, J. Connections, 2) Installing and Connecting Main Bus Conductors* the joints must be insulated as follows.

**CAUTION**

The operating temperature of conductors in the switchgear may reach 105°C. Any insulating material used in this switchgear must be suitable for this temperature.

To provide adequate bus joint insulation, use any of the following methods:

- Wrapping bus joints, using tape or heat shrink material
- Applying bus insulating boots

Figure 25  Bus Duct in Plenum
a. Tighten the bus bar splice plate bolts properly. See Table D, Bolt Torque Values. Once the joints are insulated, it will not be possible to retorque the bolts without removing the boot.
b. Place the boot over the joint (Figure 26).

c. Align holes of each side of the boot
d. Thread tie wraps through the holes and pull tight, creating a seal (Figure 27, a).
e. An alternative method of assembly uses push rivets (Figure 27, b). Push the rivets completely through on both sides of the boot. Verify the edges of the boot seal.

4) Wrapping of Joints

The following insulation system involves the use of high voltage insulating tape and electrical grade rubber-based (B) putty*. The high voltage tape will be used both as a filler and also as the final insulation covering. Overlap any expired roll by ½ turn.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0282A3529 P004</td>
<td>2&quot; wide tape</td>
</tr>
<tr>
<td>0282A3529 P005</td>
<td>4&quot; wide tape</td>
</tr>
<tr>
<td>0282A3529 P008</td>
<td>Electrical grade rubber-based (RB) putty</td>
</tr>
</tbody>
</table>

Note: Electrical grade RB putty will be used only when required to grade voids and smooth out sharp edges of joints and pothead, terminator or entrance bushing connections.
a. **Bus Bars 5kV & 15kV**

Apply appropriate number of layers of high voltage tape, mastic side down, at a medium tension to bus bars per Table E, Bus Wrapping Components.

**Note:** All bus bars are to be round edge type.

b. **Taped Joints 5kV & 15kV**

i. **Filler** - Apply three (3) layers - ½ lap of high voltage tape, mastic side down at medium tension over all bolt heads, nuts, bars, and splice plates to form a smooth surface for taping. Any bars with sharp burrs and edges must be deburred and smoothed before applying tape.

ii. **Outerwrap** - Apply two (2) layers, ½ lap of high voltage tape, mastic side down, maintaining a medium tension on the tape while wrapping. Begin the wrap away from the joints, overlapping the adjacent insulation, (epoxy, thermoplastic sleeving, cable or tape) by three (3) inches minimum. Where potheads or bushings, etc. are to be wrapped, the tape must overlap the first skirt. When completing the wrapping of the joint, do not keep tension on the last 2” or 3” tape. The last few inches should be laid in place without tension. This will prevent the tape end from lifting.

No other taping or paint is required.

**Note:** Medium tension stretches and reduces 0.030”x2” tape to approximately 0.024”x1⅓” and 0.030”x4” stretches and reduces to approximately 0.024”x3⅓”.

---

**Figure 28 Insulation of Bus Bar**

**Table F Insulation of Bus Bar**

<table>
<thead>
<tr>
<th>Insulation Range (volts)</th>
<th>Number of Layers</th>
<th>Tape Width (inches)</th>
<th>Approx. Footage of Tape Required to Insulate (1) Linear Foot of Bus Bar (2’ &amp; 4’ Wide Rolls are 30’ Long)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>½ x 2</td>
</tr>
<tr>
<td>600V to 5000V</td>
<td>1 Layer - ½ Lap *</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5001V to 15000V</td>
<td>2 Layer - ½ Lap *</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Note:** Apply tape at medium tension to produce a void-free uniform build-up of tape. A medium tension stretches a 0.030”x2” tape down to 0.024”x1⅓/4” and 0.030”x4” down to 0.024”x3⅓/2”. Apply with mastic side down.

* Apply 3 layers - ½ lap for conductors passing through CT’s.
Figure 29  Single Bus Bar Connection Joint

Epoxy Insulation
Thermoplastic Sleevings or Tape Insulation

“B” - 1/2 LAP

“C”

RB Putty *

Figure 30  Double Bus Bar Connection Joint

Table G  Insulation of Single Bus Bar Connection Joint

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler ″A″</th>
<th>Outer Wrap ″B″</th>
<th>“C” (inches)</th>
<th>Approx. Number Rolls per Joint of HV Tape Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or 15</td>
<td>3 Layers HV Tape Δ</td>
<td>2 Layers HV Tape Δ</td>
<td>3</td>
<td>1 Roll HV Tape Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 Rolls HV Tape Δ</td>
</tr>
</tbody>
</table>

Note: * Electrical grade rubber base putty 0282A3529 P008 in roll form will be used to grade voids and smooth out sharp edges of joints. This putty has no insulation value. 1 roll is ½” x 1½” x 5’ long.

Δ High voltage insulating tape 0282A3529 P004 - Roll is .030 x 2” x 30’ long. Apply with mastic side down.

Table H  Insulation of Double Bus Bar Connection Joint

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler ″A″</th>
<th>Outer Wrap ″B″</th>
<th>“C” (inches)</th>
<th>Approx. Number Rolls per Joint of HV Tape Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or 15</td>
<td>RB Putty * &amp; 3 Layers HV Tape Δ</td>
<td>2 Layers HV Tape Δ</td>
<td>3</td>
<td>½ Roll RB Putty *</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 Roll HV Tape Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 Roll HV Tape Δ</td>
</tr>
</tbody>
</table>

Note: * Electrical grade rubber based putty 0282A3529 P008 in roll form will be used to grade voids and smooth out sharp edges of joints

# HV Tape 0282A3529 P005 roll is .030” x 4” x 30’ long.

Δ HV Tape 0282A3529 P004 roll is .030” x 2” x 30’ long. Apply with mastic side down.
5) Applying Bus Insulating Boots

a. Prepare all joints as outlined in *Ch 4 Installation, J. Connections.*

b. Place the bus insulating boot over the joint. The boot should fit snugly around all conductors, and flanges must contact each other in a smooth joint.

c. Secure the boot with the furnished nylon wire ties to complete the joint insulation.

**Note:** The PVC insulation boots are furnished for standard configurations. Special configuration conditions may require taped joints if bus insulating boots are not available.

d. Replace all covers previously removed during assembly of shipping splits and main bus, *Ch 4 Installation, F. Positioning the Metal-Clad Switchgear, 2) Assembly of Shipping Splits, b) Switchgear Inside a Power Control Room.*

6) Incoming Power Connections

Incoming power connections to the switchgear may be connected in various configurations depending on the equipment application. Review the elevation drawings delivered with the equipment for site specific connection details.

7) Cleaning Bus Insulation

Main bus bars are insulated with a high temperature thermoset material having excellent dielectric and mechanical properties. When cleaning is necessary, use a lint-free cloth or industrial wiper, or a vacuum cleaner to remove accumulated dust and dirt. Do not use compressed air to clean the bus. Dust and dirt removed in this manner may be blown into operating parts of the switchgear and damage bearings or other mechanisms.

---

**Table I  Insulation of Tee Connection Joint**

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler “A”</th>
<th>Outer Wrap “B”</th>
<th>“C” (inches)</th>
<th>Approx. Number of Rolls per Joint of HV Tape ∆</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RB Putty*</td>
<td>2 Layers HV Tape ∆</td>
<td>3</td>
<td>1 Roll RB Putty* &amp; 3 Layers HV Tape ∆</td>
</tr>
<tr>
<td></td>
<td>Both Ends</td>
<td></td>
<td>0.5 (12.7) Min</td>
<td>1 Roll RB Putty* &amp; 1 Roll HV Tape ∆</td>
</tr>
</tbody>
</table>

**Note:** *Electrical grade rubber based putty 0282A3529 P008 in roll form will be used to grade voids and smooth out sharp edges of joints. This putty has no insulation value. 1 roll is 1/8” x 1 1/2” x 5’ long.

∆ HV Tape 0282A3529 P004 roll is 0.30” x 2” x 30’ long. Apply with mastic side down.*
If wiping or vacuuming does not clean the bus adequately, only distilled water, denatured alcohol or isopropyl alcohol should be used to remove any foreign materials from the insulation surface. The use of other solvents may result in severe damage to the insulation system or other parts of the equipment.

K. Primary Cables

The primary cable connections in PowlVac-AR® switchgear are reached by opening the hinged rear doors. Before any primary cable connections are made, the cables should be identified to indicate their phase relationship with the switchgear connections. This is necessary to ensure that motors will rotate in the proper direction and that the phase rotation is the same when interconnecting two different sources of power.

Normally compression terminals are used to terminate primary cable. When shielded cables are used, proper stress relief must be provided at the cable termination. This may be done by the use of a commercially available cable terminator, many types of which are available, or by the use of a stress cone, either hand-built or of the prepackaged type. In all cases, carefully follow the cable manufacturer’s recommendations for installation of the type of cable being used. No insulation or stress relief materials are normally furnished for cable terminations.

Potheads may be used when it is desirable to hermetically seal the end of the cable to make a moisture proof connection between the cable and switchgear bus. A pothead also prevents seeping of oil from the end of oil impregnated varnish cambric or paper insulated cable.

1) Primary Cable Penetrations

   a. General

   All cable penetrations should be sealed to maintain the arc resistant integrity of the equipment. Small gaps will exist between the round cables when they are pulled through a bushing as a group. While these gaps are typically quite small and would be expected to release minimal by-products in the event of a fault, it is recommended that they be sealed with a material such as Bisco, or where the gaps are very small, a silicon based sealant like RTV once the cables are pulled and terminated.

   The incoming cable must not block the pressure relief venting in the vertical section where the cable is entering or the adjacent vertical sections.

   Top entry for both breakers in two-high construction should be avoided as it severely limits the area for exhausting gases in that section.

   b. Bottom Entry

   The entry point is located on the floor of the rear compartment of the switchgear. The opening is covered with a non-magnetic stainless steel (some applications use glass-polyester) cover. Remove the cover and punch it for the appropriate sized entry bushing. It is important that all of the hardware used to attach the cover to the floor of the compartment be used when reinstalling the cover.
c. **Top Entry**

Top Entry may be accomplished in a number of ways, depending on how the equipment is configured and the type of plenum (if present). Refer to *Ch 4 Installation, F. Positioning the Metal-Clad Switchgear, 3) Plenum Assembly* for details on how to identify the plenum.

i. The modular plenum (see *Ch 4 Installation, F. Positioning the Metal-Clad Switchgear*) has a provision to top entry outside the plenum over the cable compartment only. Between the rear mounting point of the plenum and the rear door frame is a removable cover to facilitate top entry. Remove the cover and punch it for the appropriate sized bushing. Using this entry blocks the rear of the plenum for an exhaust duct on that individual section.

ii. The plenum made from multiple pieces is typically found in PCR® applications where top entry from cable tray will be utilized. This plenum design may be opened on either end for the tray to pass through. The top of the equipment is penetrated as required.

**Note:** *Future capacity increases may not be possible with this design as the cable bend radius may not be possible in the confined area under the plenum.*

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**L. Insulating Primary Cable Terminations**

All field assembled joints for primary cable terminations should be prepared as outlined under *Ch 4 Installation, J. Connections*. Upon completion of the cable termination, care must be exercised when taping the exposed termination.

1. All taping of roof bushing should be insulated as outlined in *Figure 34*. See *Ch 4 Installation, P. Roof Entrance Bushing* for details.
2. The instructions for application of the tape insulation are the same as outline for wrapping of joints.
Table J  Cable Termination Joint

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler &quot;A&quot;</th>
<th>Outer Wrap &quot;B&quot;</th>
<th>&quot;C&quot; (inches)</th>
<th>Approx. No. of Rolls per Joint of HV Tape ∆</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or 15</td>
<td>RB Putty* &amp; 3 Layers HV Tape ∆</td>
<td>2 Layers HV Tape ∆</td>
<td>3</td>
<td>½ Roll Putty* &amp; 1 Roll Tape ∆</td>
</tr>
</tbody>
</table>

Note: *Electrical grade rubber-based putty 0282A3529P008 in roll form will be used to grade voids and smooth out sharp edges of joints. This putty has no insulation value. 1 roll is ½" x 1½" x 5’ long.

Δ HV Tape 0282A3529P004 roll is 0.030” x 2” x 30’ long. Apply with mastic side down.

Table K  Bar-Type Current Transformer Joint Insulation

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler &quot;A&quot;</th>
<th>Outer Wrap &quot;B&quot;</th>
<th>&quot;C&quot; (inches)</th>
<th>&quot;D&quot; (inches)</th>
<th>Approx. No. of Rolls per Joint of HV Tape ∆</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or 15</td>
<td>3 Layers HV Tape ∆</td>
<td>2 Layers HV Tape ∆</td>
<td>3</td>
<td>3 † ½ Roll HV Tape ∆</td>
<td></td>
</tr>
</tbody>
</table>

Note: *Electrical grade rubber base putty 0282A3529P008 in roll form will be used to grade voids and smooth out sharp edges of joints. This putty has no insulation value. 1 roll is ½” x 1½” x 5’ long.

† Insulate as far as possible. Do not cover polarity marks.

Δ HV Tape 0282A3529P004 roll is .030” x 2” x 30’ long. Apply with mastic side down.
M. **Ground Fault Current Transformers (Window-Type)**

Window-type current transformers are furnished where specified for sensitive protection against ground faults. These transformers are normally installed in a horizontal position directly above or below the primary cable terminals, so that the primary cable or cables can pass through them. One transformer is required for each three-phase circuit.

Where armored cable is used, the armor must be terminated and grounded before the cable passes through the transformer. Armor clamps are furnished for this purpose when specified.

When lead or other conducting sheath cable, or cable with shielding tape or braid is used, it is recommended that the sheath or shield be grounded solidly to the switchgear ground bus. The ground lead should be bonded to the sheath or shield on the side of the current transformer away from the primary terminals. In cases where the ground cannot be applied before the cable passes through the transformer, bond the lead to the sheath or shield between the transformer and the primary terminals. The ground conductor must then be passed back along the cable path through the current transformer before being connected to the ground bus.

Where potheads are used in units provided with ground fault current transformers, the pothead mountings must be insulated from ground.

N. **Control Cables**

When control conduits enter the unit from below, the conduit should not extend more than 1 inch above the floor. The control cables may be pulled through the conduits before or after the switchgear is installed.

During the initial installation of the equipment, control cables will be run throughout the switchgear. Below are the rules and requirements necessary to maintain the arc resistant rating of the equipment which must be followed when installing control wiring:

1. All control wiring that passes through an area designated as high voltage (part of the primary circuit) must be shielded or run through a wire way to maintain the metal-clad isolation requirements.
2. Control wiring passing between adjacent instrument compartments requires no special precautions with respect to the arc resistant rating.
3. When internal control wiring must pass from a high voltage area to an area designated low voltage or an area protected by an arc fault rating (such as IEEE Type 2b) there must be a seal that protects the wire ways provided in the switchgear. If this is not possible, the wire may be routed through flexible conduit that is either terminated through a compression bushing or filled with a barrier material to block the ingress of gas. PowlVac-AR® switchgear is configured with multiple wire ways to facilitate this wiring.
   a. To use the provided wire ways, remove the cover plates and run the necessary wiring. Replace the covers when complete.
b. To run the control wire outside the provided wire ways refer to *Ch 5 Operation, Q. Field Wiring and Cable Connections* for details on control wiring installation and removal and for specific details on control wire routing and allowable entry points.

4. Where the wires are to be added to existing cable bundles entering the instrument compartment (low voltage area) from the circuit breaker compartment (high voltage area), locate the CGB type bushing entering the instrument compartment that is not full. Loosen the bushing clamp and run the wiring. Retighten the bushing clamp to seal the wire entry.

5. Control wiring entry from outside the switchgear is accomplished by:
   a. Penetrating the top of any full height instrument compartment and routing the wiring through the openings provided between instrument compartments.
   b. Entering through the upper circuit breaker or auxiliary compartment entry point that routes the wiring through wire ways and into the instrument compartment below. Space in these wire ways is limited and care should be exercised to plan the routing for the entire lineup rather than modifying the entry point.
   c. It is recommended to space the control wire entry across the switchgear lineup. It is not advisable to attempt to route all control wiring through a single section unless it is the only section available.
   d. Obey all applicable codes and regulations for filling the conduit.

The cables from the control power source to the switchgear must be large enough to avoid excessive voltage drop when the circuit breakers are operated. Where units have been split for shipment, any control or other secondary leads that must connect across the split will be arranged with terminal blocks in a convenient location so that the wires can be reconnected. The wires will be cut to length and formed before being folded back so that a minimum time will be required for reconnecting them.

**NOTICE**

Prior to energizing the switchgear, a small amount of silicon filler (such as RTV) must be added between the wire bundles that enter the instrument compartment from the high voltage areas. Although these wire bundles pass through compression type bushings, there may still be small gaps and the silicon is used to completely seal the entry. The silicon is easily removable if wiring changes become necessary.

**NOTE:** There is no silicon present when the switchgear leaves the factory to facilitate customer wiring. All bushings must be inspected and sealed prior to energizing the equipment to maintain the IEEE Suffix b rating.
O. SURGE PROTECTION

It is the responsibility of the purchaser to provide suitable surge arrestors to protect the switchgear from damage due to lightning or other surges. When surge arrestors are furnished as part of the switchgear, the primary cable termination will be insulated at the factory unless it must be disconnected for shipment. When this connection is completed in the field, it will be necessary to insulate the primary connection before the switchgear is energized. Insulating boots will normally be supplied to insulate connections.

P. ROOF ENTRANCE BUSHING

When furnished, roof entrance bushings are frequently removed from the switchgear for shipment, and the mounting openings covered with shipping covers. To install the roof entrance bushings, remove and discard the shipping covers and install the roof entrance bushings in their place. Use the gasket materials furnished with the roof entrance bushings to ensure a weather proof installation.

If the bushings have fixed terminals, which cannot be rotated in the field, be sure that the bushing terminal is aligned properly before bolting the bushing in place. The mounting flanges of roof entrance bushings typically have six or more evenly spaced bolt holes, allowing adjustment every 60” or less.

When assembling the connection bar end of the roof entrance bushings inside of the switchgear and other terminations where porcelain insulators are used, insulation should be applied as follows:

1. Prepare the connection bars as outlined under Ch 4 Installation, J. Connections. Fill all cavities around the contact nuts and connection bars with Solarite KM1592 compound. Form a smooth surface for taping, thus preventing air voids. The compound is not an insulating medium and should not be used for that purpose.

2. Wrap joint with insulating tape provided, maintaining tension on the tape while wrapping as shown in Figure 34. Where there are sharp angles, apply additional layers to obtain equivalent of the insulation on the flat surfaces.

Figure 34  Roof Bushing

<table>
<thead>
<tr>
<th>Table L</th>
<th>Pothead, Bushing, or Terminator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation Level (kV)</td>
<td>Inner Filler “A”</td>
</tr>
<tr>
<td>5 or 15</td>
<td>RB Putty* &amp; 3 Layers HV Tape ∆</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * Electrical grade rubber-based putty 0282A3529P008 in roll form will be used to grade voids and smooth out sharp edges of joints. This putty has no insulation value.

1 roll is ½” x 1½” x 5’ long

Δ HV Tape 0282A3529P004 roll is 0.030” x 2” x 30’ long. Apply with mastic side down.
**Figure 35** Two-High Rollout Configuration

**Figure 36** Key Components of the Lower Rollout Compartment

- **a. Rollout Carriage**
- **b. Guide Rail**
- **c. Locking Handle**
- **d. Door Interlock**
- **e. Racking Mechanism Kirklock**
- **f. Racking Mechanism Actuator**

**Figure 37** Close Up of Rollout Mechanism Interlock
Q. **Bus Duct Entry**

Bus duct entry into the switchgear must penetrate the plenum (when a plenum is present).

1. The Standard Plenum has an alternate configuration that contains compartments designed to accommodate bus entry and maintain both metal-clad switchgear isolation and arc fault integrity. Connections to the bus are made from the outside of the equipment as is typical with standard bus duct.

2. The Barrier Type Plenum construction in a PCR® may also be configured with bus duct. The duct is not integral to the plenum. Here standard bus duct is run inside the plenum assembly and sealed as it exits the perimeter wall of the plenum.

In all cases, there will be a fire barrier inside the duct at the point it exits the boundaries of the plenum.

R. **Auxiliary Device Rollout Carriage**

It is recommended that the switchgear is deenergized before performing the following:

1. **Initial Installation (deenergized equipment)**

   All auxiliary carriages are shipped in a disconnected state to prevent damage to the primary circuit disconnecting devices during shipment.

   The carriage should be connected to the racking mechanism when received. This may be verified by the following procedure:

   ![Danger](image)

   **DO NOT PERFORM THIS TEST ON ENERGIZED EQUIPMENT!**

   Performing this test may cause the auxiliary carriage contacts to connect improperly and create an arcing fault if the equipment is energized at this time. The operator will be exposed to potentially lethal conditions should this occur.

   a. Remove the tie-wrap or other locking mechanism (*Figure 23*) if present. Insert the handle into the racking mechanism.

   b. While holding the racking handle so that it cannot move, attempt to push the auxiliary carriage into the compartment, toward the "Connected" position. It should not move. If it does, refer to Ch 4 Installation, R. Auxiliary Device Rollout Carriage, 2) Connecting the Auxiliary Carriage to the Racking Mechanism.

   c. Operate the racking handle to the connected position. The auxiliary carriage should move to the rear of the compartment until the front cover of the carriage is approximately flush with the frame of the compartment. If it does not, refer to Ch 4 Installation, R. Auxiliary Device Rollout Carriage, 2) Connecting the Auxiliary Carriage to the Racking Mechanism.
d. Release and remove the racking handle and attempt to pull the carriage out of the "Connected" position. Again, it should not move. If it does, refer to Ch 4 Installation, R. Auxiliary Device Rollout Carriage, 2) Connecting the Auxiliary Carriage to the Racking Mechanism.

2) Connecting the Auxiliary Carriage to the Racking Mechanism

**WARNING**

To perform this action the auxiliary compartment door must be open. If the equipment is energized at this time, the operator is exposed to potentially lethal conditions. The operator must wear the appropriate PPE for the level of flash hazard exposure indicated by the short-circuit rating of the equipment if working on energized equipment.

a. Hold the racking mechanism in the disconnected position by inserting the handle and rotating to the right. Use the handle to maintain leverage on the actuator.

b. Slide the locking bar on the auxiliary carriage to the right and push the carriage on the roller arm of the racking mechanism.

c. Once the carriage is in place on the mechanism, the locking bar can be released and it will secure the roller arm in the guide track on the bottom of the carriage.

d. If the carriage contains fuses for a remote mounted CPT or contains the CPT and fuses, the interlock for the secondary load circuit breaker must be released to make the carriage operational.

a) Locate the secondary side circuit breaker and verify it is in the open position.

b) Lock the circuit breaker in the open position and use the key to release the interlock on the auxiliary carriage.

ii. If the carriage contains voltage transformers only, there will be no interlock and it is ready to be operated.

**WARNING**

At this point the auxiliary carriage may be racked into the connected position with the compartment door open. If the equipment is energized, the operator is exposed to potentially lethal conditions. The operator must wear the appropriate PPE for the level of flash hazard exposure indicated by the short-circuit rating of the equipment if working on energized equipment.

d. Close and latch the equipment door to return the equipment to the arc resistant state.

e. The auxiliary carriage may now be racked into the connected position following the appropriate procedure for the type of device mounted on the carriage (see below).
3) Racking the Auxiliary Carriage

Normal operation of a voltage transformer (VT), control power transformer (CPT), or fuse rollout carriage involves moving the device between the connected (energized) position and the disconnected position. This activity may be accomplished as follows:

a. Voltage Transformer (VT)
   i. Confirm that this operation is required and follow the site specific practice for performing this operation.
   ii. Release any locks or interlocks associated with the racking mechanism.
   iii. Insert the racking handle into the mechanism.
   iv. Move the handle in the direction indicated by the nameplate (Figure 39, a) to move the carriage to the desired position in one smooth, continuous motion.
   v. Remove the handle.

Figure 38  Racking the Lower Auxiliary Device

Figure 39  Racking the Upper Auxiliary Device

a. Nameplate

![Warning]

**WARNING**

Racking an auxiliary carriage containing either a control power transformer or the fuses for a fixed mounted control power transformer will require operation of an interlock mounted on the front of the carriage. This will require the operator to open the arc resistant door to access the interlock. If the equipment is energized, the operator is exposed to potentially lethal conditions. The operator must wear the appropriate PPE for the level of flash hazard exposure indicated by the short-circuit rating of the equipment if working on energized equipment.
b. **Control Power Transformer (CPT) with Fuses**

i. Confirm that this operation is required and follow the site specific practice for performing this operation.

ii. The secondary circuit breaker is typically located in the low voltage or instrument compartment. Locate the circuit breaker and operate it to the open position.

iii. Use the interlock to lock the circuit breaker in the open position.

iv. Remove the key from the interlock.

v. Using the key, release the interlock that holds the auxiliary device racking mechanism in the connected position.

vi. Insert the racking handle into the mechanism.

vii. Move the handle in the direction indicated by the nameplate (*Figure 39, a*) to move the carriage to the desired position in a continuous motion.

viii. Remove the handle.

All other activities, including fuse replacement are considered maintenance operations and require that the arc resistant door be opened to perform. The operator must always wear the appropriate PPE when performing these activities.

c. **Fuse Rollout for Fixed-Mounted Transformer**

i. Confirm that this operation is required and follow the site specific practice for performing this operation.

ii. The secondary circuit breaker is typically located in the low voltage or instrument compartment. Locate the circuit breaker and operate it to the open condition.

iii. Use the interlock to lock the circuit breaker in the open position.

iv. Remove the key from the interlock.
4) **Removing the Auxiliary Carriage From the Upper and Lower Compartments**

**WARNING**

To perform this action the auxiliary compartment door must be open. If the equipment is energized at this time, the operator is exposed to potentially lethal conditions. The operator must wear the appropriate PPE for the level of flash hazard exposure indicated by the short-circuit rating of the equipment if working on energized equipment.

Should it become necessary to remove the carriage from the switchgear for maintenance, fuse replacement, or other activities, perform the following:

**CAUTION**

When removing an auxiliary device from the upper compartment, these additional precautions should be followed:

a. **Perform this task with at least two people.**

b. **Performing this task may require additional equipment for working above the floor, such as a ladder or safety harness. Consult with local regulations for work above grade.**

a. Place the auxiliary carriage in the disconnected position by using the appropriate method described in Ch 4 Installation, R. Auxiliary Device Rollout Carriage, 3) Racking the Auxiliary Carriage, c. Fuse Rollout for Fixed-Mounted Transformer.

b. Remove the racking handle and open the compartment door.
c. A lifting device is required to remove the auxiliary carriage. Follow the instructions found in the Instruction Bulletin for the specific lifting device. 
d. Close and latch the compartment door.

5) Placing the Auxiliary Carriage Into the Upper and Lower Compartments

**WARNING**

To perform this action the auxiliary compartment door must be open. If the equipment is energized at this time, the operator is exposed to potentially lethal conditions. The operator must wear the appropriate PPE for the level of flash hazard exposure indicated by the short-circuit rating of the equipment if working on energized equipment.

**CAUTION**

When placing an auxiliary device into the upper compartment, these additional precautions should be followed:

a. Perform this task with at least two people.

b. Performing this task may require additional equipment for working above the floor, such as a ladder or safety harness. Consult with local regulations for work above grade.

c. Confirm the closed-door racking device is in the disconnected position. If it is not, operate the closed-door racking device to the disconnected position by inserting the handle and rotating the mechanism into position. Remove the handle.

d. Open the compartment door.

c. A lifting device is required to install the auxiliary carriage. Follow the instructions found in the Instruction Bulletin for the specific lifting device.

d. Latch the auxiliary carriage on the closed-door racking mechanism as described in Ch 4 Installation, R. Auxiliary Device Rollout Carriage, 2) Connecting the Auxiliary Carriage to the Racking Mechanism.

e. Close and latch the compartment door. The auxiliary carriage may now be racked into the connected position.
Ch 5  Operation

DANGER

Compartment access shall be permitted ONLY to “Qualified Person”, as defined in NFPA 70E, using “approved safe work practice” and “appropriate PPE”.

A. GENERAL

All removable elements of the same type, rating, and duplicate wiring may be interchanged.

During operation, all live parts are enclosed by barriers which permits the user to perform maintenance with maximum safety. Separate covers are provided over each compartment, so that any compartment of housing may be exposed without exposing other compartments.

All PowlVac® vacuum circuit breakers are equipped for electrical operation. A manual charging handle is supplied as part of the accessories to permit manual operation of the circuit breaker during maintenance.

CAUTION

This device must not be used to close the circuit breaker on any energized circuit.

The control circuits may be checked by moving the circuit breaker to the test position where the main circuits are disconnected and the control circuits are complete.

B. INSERTING THE REMOVABLE ELEMENT INTO THE COMPARTMENT

WARNING

Opening the circuit breaker compartment door to install a circuit breaker exposes the operator to potentially lethal conditions by removing the arc resistant protection during the time the door is open and unlatched. The operator must wear the appropriate Personal Protective Equipment (PPE) for the level of flash hazard exposure indicated by the short-circuit rating of the equipment.

Refer to the applicable circuit breaker instruction bulletin and drawings produced specifically for the installed equipment for additional information and cautions before attempting to insert the circuit breaker into the metal-clad switchgear equipment.

NOTICE

Be sure that the racking crank arms at the sides of the circuit breaker point in the direction of the primary disconnecting devices and the circuit breaker position indicator displays breaker test/disconnected.
Each circuit breaker and metal-clad switchgear is provided with interference plates which are designed to ensure that no circuit breaker with less than the required voltage, continuous current, or interrupting current rating is placed in the incorrect circuit breaker compartment. If you attempt to insert an improperly rated circuit breaker into the circuit breaker compartment, these plates will interfere with each other and deter further insertion. The interference will occur before the circuit breaker reaches the disconnected position. Note that the 4000A circuit breaker compartment is elevated off the floor and will require the use of a lifting device to install or remove the circuit breaker. Do not attempt to force the circuit breaker past the compartment interference plate or remove the interference plates from either the compartment or the circuit breaker. Remove the incorrectly rated circuit breaker and insert a properly rated circuit breaker into the metal-clad switchgear.

1) Prior to Inserting the Circuit Breaker into the Circuit Breaker Compartment

a. Check the Primary Disconnecting Devices and Circuit Breaker Compartment

Examine the primary disconnecting devices for any signs of damage and contamination. Check to see that none are bent out of alignment. If contamination is found refer to Ch 6 Maintenance, B. Overall Maintenance Procedures for cleaning and lubrication procedures. If the primary disconnecting devices are damaged make no attempt to repair. Contact Powell for further information.

Examine the circuit breaker compartment to see that it is clean and clear of debris that might interfere with circuit breaker travel.

b. Racking the Circuit Breaker into the Circuit Breaker Compartment

The circuit breaker may be racked manually or electrically using the optional Power Racking device.

The circuit breaker is designed to be manually racked into the circuit breaker compartment with the compartment door closed. The optional Power Racking device may be fitted on the closed circuit breaker compartment door to eliminate manual operation.

CAUTION

Before inserting any circuit breaker into a compartment, the user must verify that the circuit breaker rating meets or exceeds the metal-clad switchgear rating.

CAUTION

Before inserting a circuit breaker into the circuit breaker compartment, be sure that the indicator flag on the front cover of the circuit breaker displays “BREAKER TEST/DISCONNECTED”.

CAUTION

Before attempting to rack a circuit breaker in or out of a circuit breaker compartment equipped with a key interlock, make sure that the interlock is unlocked and in the open position.
C. **Racking Mechanism**

The racking mechanism consists of two slotted cam plates mounted on each side of the compartment (located behind the shutter actuators shown in *Figures 8, c & 9, c*) and the racking mechanism on the circuit breaker. The crank arm rollers at the ends of the racking crank arms of the circuit breaker will engage the cam plates in the compartment and the act of moving the circuit breaker from one position to another can be performed. The procedure that moves the circuit breaker from one position to another is known as “racking”. Arc resistant switchgear requires this procedure be performed with the compartment door closed for normal operation via one of the following options:

1) **Closed-Door Racking**

This is the standard for arc resistant switchgear. The front door of the circuit breaker compartment has an opening which enables the racking shaft of the circuit breaker to be accessed with the door closed and latched. The shaft is held captive and sealed to the door to maintain the arc resistant integrity. The opening is covered by a teardrop cover (*Figure 1, d*) which automatically closes by gravity when the racking handle is removed. The door is also provided with a viewing window (*Figure 1, c*) and the compartment light (*Figure 8, a*) to allow viewing the position and condition of the circuit breaker without opening the door.

2) **Remote Racking Device**

The closed-door racking design allows the use of remote racking devices. The door is equipped with the appropriate connection points to mount an external motorized racking device. Contact Powell for appropriate device and instructions.

3) **Onboard Racking**

This design utilizes a circuit breaker equipped with an automatic racking system and requires no front door access. Mechanical operation of this racking method requires the compartment door be open and such operation should only be made in an emergency or with the switchgear deenergized.

D. **Racking Procedure (Manual)**

![CAUTION]

**Use only the racking tools provided by Powell for inserting and removing the circuit breaker. The use of other tools such as electric drills, impact drills, etc., may damage the racking mechanism and render it inoperative.**

![CAUTION]

**Before inserting the circuit breaker into the compartment, be sure that the racking crank arms of the circuit breaker are in the fully withdrawn position, pointing towards the movable primary disconnects. Otherwise, the primary disconnects, shutters, or the racking mechanisms may be damaged.**

![CAUTION]

**Before racking a circuit breaker in or out of the compartment, make sure that the key interlock is unlocked and in the opened position. Otherwise, the racking mechanism may be damaged.**
Refer to the applicable circuit breaker instruction bulletin and drawings produced specifically for the installed equipment for information and cautions before attempting to rack the circuit breaker into the metal-clad switchgear equipment.

E. RACKING PROCEDURE (ELECTRICAL)

This is an alternative to the manual racking procedures described in Ch 5 Operation, D. Racking Procedure (Manual) utilizing a motor driven mechanism and electric control, allowing the user to perform the racking function without being located in front of the circuit breaker compartment. The remote racking device mounts onto the compartment door. Refer to the instruction bulletin provided with the remote racking device for the proper operational procedure.

F. INTERLOCKS

PowlVac-AR® utilizes a series of interlocks to prevent misoperation and maintain the arc resistant integrity of the switchgear. These interlocks operate in conjunction with the position of the safety shutters, the circuit breaker and the compartment door. Visual indication of operation is provided on the compartment door.

1) Closed-Door Racking Interlock

This interlock prevents racking the circuit breaker into the compartment with the door open. It is located on the right side wall of the circuit breaker compartment. A plunger contacts the door when the door is completely closed and latched, releasing the interlock and allowing the circuit breaker racking mechanism to enter the racking hooks mounted on the switchgear side walls.

This interlock may also be equipped with a padlock or key lock, mounted on the interlock housing, for use as a compartment lockout.

WARNING

Opening the circuit breaker compartment door to install a circuit breaker exposes the operator to potentially lethal conditions by removing the arc resistant protection during the time the door is open and unlatched. The operator must wear the appropriate Personal Protective Equipment (PPE) for the level of flash hazard exposure indicated by the short-circuit rating of the equipment.

This interlock may be defeated by actuating the interlock plunger and racking the circuit breaker into the connected position.

a. Place the circuit breaker in the compartment as described in the normal racking procedure but do not close the door.

b. Press the lower of the two plunger assemblies on the interlock toward the rear of the compartment until it stops; holding the plunger there.

c. Begin racking the circuit breaker.

d. After a turn or two on the racking shaft, the second plunger will move back toward the rear of the compartment.

e. This indicates the safety shutters are open and the first operator can release the lower interlock plunger.

Note: The circuit breaker may only be moved out of the connected position if it is in the open condition. Moving the circuit breaker back to the test position and closing the door resets the interlock.
The racking shaft on the circuit breaker does not necessarily extend properly when the breaker is racked with the interlock defeated. Extending the shaft and closing the compartment door does not guarantee proper alignment of the door and racking shaft. If misaligned, the equipment is no longer arc resistant.

CAUTION

Closing the door on a circuit breaker already racked into the connected position causes the door interlock to reset and lock the door closed. The racking shaft may not be accessible in this situation as it is not held captive by the door latching mechanism.

Note: If the shutters are blocked open for maintenance activities and the compartment door is closed, this interlock must be defeated to reopen the door. Should the safety shutters misoperate and remain open during operation, the interlock will remain active and prevent access to the compartment.

2) Safety Shutter/Door Interlock

This interlock prevents opening the compartment door with the safety shutters open; i.e. the circuit breaker in any position except the test position. It is located on the right side wall of the circuit breaker compartment (Figure 9, f). A plunger on the interlock contacts a target on the door (Figures 4, c; 5, d, & 6, d) when the door is completely closed and latched, releasing the interlock and allowing the door to be opened. When the circuit breaker moves away from the test position, the safety shutters open, and the interlock is activated. This action is indicated by the safety shutter indicator flag changing from “green” to “red”.

This interlock may be defeated by removing the hardware indicated in Figure 43 and actuating the interlock by pushing a small screwdriver or center punch into the hole until the shutter position indicator flag changes from “red” to “green”.

Figure 43 Step One of Defeating the Shutter Interlock
3) Rear Door Interlock (Optional)

This interlock prevents opening the rear compartment door(s) when the circuit breaker is in the connected position. The interlock consists of two components; the actuator, located in the left rear of the circuit breaker compartment, and the interlock, located just inside the door on the right of the compartment bottom flange of the rear compartment. A latch hook engages the rear door when the circuit breaker feeding that compartment is in the connected position and prevents the door from being opened.

To access the rear compartment, the circuit breaker must be tripped and racked out.

The interlock (Figure 45) is spring loaded to allow automatic resetting of the interlock function if the rear compartment door is to be closed after the circuit breaker is racked to the connected position.

**DANGER**

**Racking the circuit breaker feeding the rear compartment to the disconnected position does not ensure that the cables and other components in the compartment are deenergized.**

**The operator may be exposed to potentially lethal voltages and must check for the presence of voltage using an approved method prior to performing any action that requires entering the compartment.**

**The operator must wear the appropriate PPE for the level of exposure indicated by the Arc Flash Studies (AFS) for the equipment.**

**DANGER**

**Opening the rear compartment door exposes the operator to potentially lethal conditions by removing the arc resistant protection during the time the door is open and unlatched. The operator must wear the appropriate PPE for the level of exposure indicated by the Arc Flash Studies (AFS) for the equipment.**
This interlock may be defeated in an emergency using the following procedure:

a. If the rear door is equipped with tie-down bolts on the perimeter, remove these bolts. These bolts should be captive on the door. It is not necessary to completely remove them but they must be completely removed from their tapped insert to open the door.

b. Remove the \( \frac{3}{8} \times 16 \) hex head screw on the rear door lower right corner (Figure 46).

c. Using a small flat blade screwdriver the interlock latch hook may be accessed directly through the opening (Figure 47).

i. Insert the screwdriver approximately 2 inches until contact is made with the latch.

ii. Rock the point of the screwdriver down to move the latch. There should be some resistance from the spring pushing up as this is being performed.

iii. Rotate the door handle and pull gently on the door. The door should open.

---

**DANGER**

The operator may be exposed to potentially lethal voltages and must check for the presence of voltage using an approved method prior to performing any action that requires entering the compartment.

The operator must wear the appropriate PPE for the level of exposure indicated by the Arc Flash Studies (AFS) for the equipment.

---

**G. ELECTRICAL OPERATION**

1. A one-line or three-line diagram and a schematic diagram are prepared for each switchgear lineup. All diagrams shall be thoroughly studied and completely understood by the user before the switchgear is placed into service.
2. The reading of indicating, recording instruments, and meters is common knowledge to electrically trained personnel. The use of instrument, rheostat control, and governor motor control switches are also common. Synchronizing switches are usually provided on generator and incoming line units with a synchronizing switch contact which is wired in series with the circuit breaker control switch “close” contact. The synchronizing switch should always be turned “on” first and the circuits adjusted should be in synch as indicated by the synchroscope before the circuit breaker is closed.

3. A green light indicates that the circuit breaker is open and a red light indicates that the circuit breaker is closed. For the DC control schemes, the red light is also arranged to supervise the trip coil and indicate that the trip coil circuit has continuity.

H. ShuttErS

Metal shutters (Figure 7, b) cover the primary disconnect contact when the removable element is withdrawn from the compartment.

Cam plates located on each side of the compartment are operated by the circuit breaker crank are rollers which will then operate the switchgear shutters. As the circuit breaker mechanism is operated past the disconnected position, the crank arm rollers will move the cam plates downward and open the shutters before the circuit breaker starts its forward travel to the connected position. When the circuit breaker is racked to the disconnected position, the shutters are returned to their closed position by springs attached to the cam plates.

Provisions for padlocking the shutters in the closed position are furnished on each of the two cam plates and on the front of the shutter interlock (Figure 9, f). The interlock may also be fitted with a permanent key lock for this purpose. Padlocking either of the two cam plates or the interlock will deter opening of the shutters.

I. Floor Pan

Each compartment is equipped with a floor pan which the removable element rolls on. Each side of the pan is designed with channels, which the wheels of the removable element rolls into. The width between the channels will align the removable element laterally as it is rolled in the compartment.

The top flanges of the channel deter any tipping or vertical movement of the removable element. A rollout stop block is welded to the top of the right channel of the floor pan. When a removable element is rolled into the compartment, the rollout latch on the lower right side of the removable element will drop behind this rollout stop block, and deter the removal of the removable element until this latch is manually depressed.
J. **Truck Operated Cell Switch (TOC)**  
*(Optional)*

The purpose of the truck operated cell switch is to indicate whether or not the removable element is in the connected position. When required, the switch is mounted in the upper right corner in the secondary compartment. A TOC operating pin mounted on the upper right corner of the removable element, just behind the front cover, engages the operating arm of the TOC switch and operates the switch as the removable element moves from the test position to the connected position. When the removable element is withdrawn, the spring return mechanism of the switch returns to its original position.

---

**CAUTION**

Before attempting to rack a removable element in or out of a compartment equipped with a removable element key interlock, make sure that the interlock has been unlocked, and in the open position. Otherwise, the racking mechanism may be damaged.

---

K. **Mechanism Operated Cell Switch (MOC)**  
*(Optional)*

The mechanism operated cell switch *(Figure 48)* is an auxiliary switch that is operated by the linkages in the compartment, which operates in conjunction with the circuit breaker mechanism.

MOC switch operating arm which project from the jackshaft of the circuit breaker at the lower left side of the circuit breaker operates in conjunction with the MOC assembly. This rides over an angle pivoted on the lower left side sheet of the compartment. When the circuit breaker is closed, the arm moves downward, deflecting the angle.

A linkage connects the switch to the angle, and the whole assembly is spring-loaded to the open position. The switch is mounted in the compartment near the upper left corner, and the operating linkage extends downward to the pivoted angle.

As supplied, the mechanism operated cell (MOC) switch will operate with the removable element in either the connected or the test position. If it is desired that the switch operate in the connected position only, remove the small bolted-on angle that forms the bottom flange at the front of the pivoted angle.

*(Figure 48) Mechanism Operated Cell (MOC) Switch*

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a. Mechanism Operated Cell (MOC) Switch  
b. MOC Actuator
L. **Secondary Disconnect Device**

1) *Standard PowlVac-AR®*

The switchgear has a secondary disconnect device, which is a plug mounted at the lower end of an umbilical cord (*Figure 49, c*) and is stored in the right side of the compartment (*Figure 49, a*). The secondary disconnect plug connects into the secondary disconnect receptacle on the lower right front of the circuit breaker.

**Figure 49  Circuit Breaker Compartment**

Interlocks are provided to deter misoperation of the circuit breaker. These interlocks function as follows:

1. The secondary disconnect plug must be inserted into the secondary disconnect receptacle when the circuit breaker is in the disconnected position in order to rack the circuit breaker from the test position.
2. The secondary disconnect plug must be inserted into the secondary disconnect receptacle to operate the circuit breaker in the test position.
3. The secondary disconnect plug may be withdrawn with the circuit breaker in the test position, by depressing the secondary disconnect guide, which holds the plug in place, and pulling straight out on the plug handle to disconnect the secondary disconnect plug. The circuit breaker cannot be operated or racked in either direction with the plug withdrawn. Removing the plug will open a closed circuit breaker and discharge the closing spring if it is charged.
4. The secondary disconnect devices must be completed to enable the act of racking the circuit breaker between the test position and the connected position. During this act, the plug is held captive and cannot be withdrawn until the circuit breaker returns to the test position or the connected position.

---

- a. **Secondary Disconnect Storage Position**
- b. **Mechanism Operated Cell (MOC) Switch**
- c. **Secondary Disconnect Umbilical Cord**
- d. **Wire Way**
- e. **Control Cable Entry Cover**
- f. **Compartment Door Interlock**
- g. **Interference Plate**
- h. **Conduit Entry**
2) PowlVac-AR Equipped with PowlVac CDA Circuit Breaker

Control power is transferred from the metal-clad switchgear to the circuit breaker by means of the secondary disconnect device. The secondary disconnect receptacle is located on the top of the circuit breaker. The secondary disconnect plug is attached to the switchgear and is located on the shelf above the circuit breaker compartment. This arrangement allows the secondary connection to be visible in all positions of the circuit breaker.

M. REMOVABLE ELEMENT KEY INTERLOCK (OPTIONAL)

The removable element key interlock is a mechanical, manually operated assembly designed to deter movement of the removable element from one position to another. The interlock may be secured either by padlocks or by key interlocks. The interlock consists of an L-shaped steel bar with support brackets, and a lock provisions. The interlock is held by gravity in the open, or non-interlock position. When the removable element is out of the compartment, rotating the interlock 90° clockwise, and securing it will block the insertion of a removable element.

N. DUMMY BREAKER

Dummy breakers are used as a means of isolating circuits or bus sections, where operation is infrequent and a circuit breaker cannot be economically justified. The dummy breaker consists of a framework, and primary disconnects which simulates the circuit breaker removable element. The front ends of the primary disconnects are connected, top to bottom, by copper bars which are fully isolated. The stationary structure is the same as for the circuit breaker, except that no secondary disconnect device or control devices are provided. When the dummy breaker is racked into position, it connects the upper set of the switchgear primary disconnect devices to the lower set.

WARNING

Under no conditions must the dummy removable element be racked in or out when the unit is carrying a load current, a significant capacitive, or an inductive charging current.

Key interlocks are applied to ensure that all source of power is disconnected before operating the dummy breaker. The key interlock used is similar to that described in Ch 5 Operation, M. Removable Element Key Interlock (Optional) and is set up for “lock in and out” mode of operation.

The interference plates provided on the dummy breaker will deter the insertion of an element of lower continuous current rating in a higher rated compartment. Further, these plates deter the insertion of any dummy breaker into any circuit breaker compartment. It may be possible to insert a circuit breaker into the designated dummy breaker, however, because there is no secondary disconnect present in the compartment, the circuit breaker cannot be operated or racked into the connected position.

O. GROUND AND TEST DEVICE, THE REMOVABLE ELEMENT

The PowlVac-AR® ground and test device is a removable element which is mounted on a frame similar to the frame of a circuit breaker, and it can be substituted for a circuit breaker in the switchgear. It is equipped with a ground contact, primary disconnects, grounding cables, test ports, wheels, and can be operated manually or electrically.
The ground and test device provides a means for obtaining access to the primary disconnect devices of the circuit breaker compartment for the purpose of grounding the primary circuits, conducting certain high voltage withstand tests (hipot). Insulation and isolation barriers between phases, and between phase and ground are also provided where required.

Closed-door racking interlocks must be temporarily defeated for racking grounding or testing devices into the circuit breaker compartment. The use of grounding and testing devices requires access to the front of the devices to allow connection of remote electrical control to the grounding device or connection of test equipment to the testing device. To gain access to the front of these devices the breaker compartment door must remain open during use. Refer to *Ch 5 Operation, F. Interlocks, 1) Closed-Door Racking Interlocks* for the procedure to defeat the interlock.

**P. Test and Inspection**

Contact Powell Service Division for testing and inspection assistance.

After the switchgear lineup has been installed and all connections made, it should be tested and inspected before placing the lineup into service. Although the switchgear and devices have been completely tested at the factory, a final field test should be made to ensure that the switchgear lineup has been properly installed, and that connections are correct, and have not become loose during transportation. The primary circuits to the switchgear lineup should be completely deenergized while the tests are in progress.

Directions for testing devices, such as relays, instruments and meters are given in the instruction bulletin furnished for each device. The settings for the protective relays must be coordinated with other relays in the system, and therefore, the purchaser must set these relays.

When transformers are furnished to supply the control power, the primary taps should be selected so that the control voltage indicated on the wiring diagram is obtained on the secondary of the transformer. When a battery is used to supply the control power, the cables from the battery of the switchgear should be large enough to avoid excessive voltage drop. The voltage at the terminals of the circuit breaker closing coils, when the circuit breaker is being closed, should not be less than 43.2 volts for 48 volt coils, 112.5 volts for 125 volt coils, or 225 volts for 250 volt coils.

Make a rough check of engagement between all moving and stationary contacts in both the connected and disconnected (or grounded) positions. This contact engagement may be checked simply by “lighting-out” or “ringing-out” with a flashlight or bell. Contact engagements is factory adjusted and normal circumstances will check out properly.

The switchgear should be given a final check and tested before being placed into service. Extreme care must be exercised to prevent the equipment fed from the switchgear from being connected to the system while the preliminary tests are being conducted.
The testing equipment that is needed will depend on the size and type of installation. Test equipment is not in the normal scope of the supply of the switchgear, but may be supplied as an option, or may be rented from various sources. Portable voltmeters will be required. For large and complicated installations, ammeters should be readily available in case unexpected trouble develops. Some simple portable devices for “ringing” or “lighting-out” circuits should be included in the testing equipment.

Wire connections, accessible bolted bus connections, and insulated joints should be examined to make sure that the connections have not become loose, or damaged during shipment or installation.

Connections to the equipment remote from the switchgear, such as instrument transformers, remote control and interlock circuits, auxiliary switches, etc., should be “lighted out” to verify the connections are correct. The extent to which this will have to be done depends on the thoroughness of the installation maintenance. There must be definite assurance that connections are correct before an attempt is made to operate the equipment.

As a final check before energizing the equipment, the insulation integrity of the high voltage circuits should be verified with a high voltage (2500V or greater) megohmeter. All portions of the high voltage circuits should be checked, both phase-to-phase and phase-to-ground. This check will verify that there is no major insulation damage due to shipping, handling, or installation.

If a more stringent test of insulation integrity is desired, an AC high potential test is recommended. Perform the one minute low frequency withstand test described in ANSI Standard C37.20.2, at the voltage level appropriate for the equipment, 14.25kV for equipment rated 4.16kV or 27kV for equipment rated 7.2kV or 13.8kV.

Note: These values are 75% of the factory high potential test values.

DC high potential testing is not recommended; however, if it is required, the voltage level appropriate for the equipment must be used. These are 20kV for equipment rated 4.16kV or 38kV for equipment rated 7.2kV or 13.8kV. The DC high potential test machine must not produce instantaneous peak voltages exceeding 50kV. For further information on DC high potential testing, refer to the separate instructions for the PowlVac® vacuum circuit breakers.

The covers for meters, relays, and other devices that have been removed during the course of installation and test should be carefully handled when removed. The covers should be put back in place, promptly to keep dust and dirt from collecting on the vital relay parts.

After the switchgear has been installed, and put into operation, the drawings supplied with the switchgear lineup should be studied and reviewed, and compared to any notations made on them of any deviation made during or before time of installation.
Q. **FIELD WIRING AND CABLE CONNECTIONS**

**WARNING**

Before any adjustment, servicing, parts replacement, or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, THE POWER SUPPLY MUST BE DISCONNECTED.

**WARNING**

Do not route any control cables in any manor or in any location which may impede the function of the interlocks, pressure relief vents, or any other moving part of the assembly.

1) **Adding Control Cable**

PowlVac-AR® arc resistant switchgear conforms to ANSI requirements for metal-clad switchgear and all wiring must meet the requirements of ANSI C37.20.2. Additional precautions are required to maintain the integrity of the arc resistant features. The general guidelines for adding control cables to arc resistant switchgear are as follows:

a. All penetrations into arc resistant switchgear from external sources must be made through sealed conduit or protective bushings into the instrument compartment or designated entry point (Figure 50).

b. The preferred entry into the switchgear is through the top of a full height instrument compartment or into the side of the end unit instrument compartment.

c. All interconnections between vertical sections should be run internally through the openings between instrument compartments (Figure 51).
Penetrations through the floor are best made in the center compartment directly behind the circuit breaker barrier. Cables in this area must be either shielded, enclosed in conduit, or covered by a grounded metal barrier to meet the requirements of metal-clad equipment. These cables must not extend into the area occupied by the circuit breaker.

ii. Front compartment penetration on the left side of the compartment is discouraged because of the close proximity of the MOC actuator (Figure 48, b). Front compartment penetration on the right side is limited due to the front door interlock assembly (Figure 49, f).

Note: The MOC actuator pivots with the operation of the circuit breaker. Do not route any wires above the level of the floor pan side wall and directly under the MOC actuator.

iii. Penetrations in the area directly behind the circuit breaker beneath the primary disconnecting devices are the preferred method of entry into this compartment. This is accomplished by removing the cover box (Figure 49, e) and making the appropriate conduit penetration openings in the cutout panel provided. The cables are shielded by replacing the cover box. Cables entering the compartment are routed through an opening in the left side of the breaker floor pan and in the wire way formed by this pan and the left side wall. A cover is provided to shield the wires in the wire way.
**Note:** Installation of a rear door interlock will limit the accessibility of this wire way as the interlock shares the available space. Contact Powell for specific instructions if the wires and interlock cannot be fitted in the available space.

iv. All penetrations into the center compartment (circuit breaker compartment) must be routed into the front compartment through either the vertical side barriers or the shelf directly above the circuit breaker. No special precautions are required other than use of a bushing or similar device to protect the wires as they pass through the metal barrier.

v. Entry into the instrument compartment is made as described in *Ch 5 Operation, Q. Field Wire and Cable Connections, 1) Adding Control Cable, d.*

f. In all cases, the control cable and its shielding method must not compromise the safe distances between energized conductor and ground for the rating of the equipment. The recommended minimum distances are:
   - 3 ½” for equipment rated up to 5kV
   - 6” for equipment rated up 15kV

   These values may be superseded by any local or national regulation or requirement specific to the job site and are given only as guidance in the absence of any other requirements.

**R. Control Cable Removal**

1) General

Removing control cables from an arc resistant switchgear design requires that the opening created by the removal be blocked to prevent the transfer of products from an arcing fault into areas intended to be protected by the rated type of equipment.

Recommended methods for blocking the openings are as follows:

a. Partial removal of cables from a CGB fitting:
   i. For removal of small quantities of cable, the CGB may be tightened to further compress the gasket.
   ii. For removal of larger quantities of cable, the CGB may be fitted with a smaller size gasket or a smaller CGB must be installed.
   iii. Abandon the cable(s) in place. Disconnect and tie-back both ends.

b. Partial removal from conduit or solid fitting:
   i. Abandon the cable in place. Disconnect and tie-back both ends.

c. Complete removal of all cables from any fitting is accomplished as follows:
   i. Remove all cables and the fitting.
   ii. Fill the opening left by removal of the fitting with a steel cover plate (do not use aluminum). A minimum thickness of 11 gauge (0.119”) is recommended. Smaller openings may be filled with the largest bolt which will fit in the opening, with flat washers on both sides of the wall.
iii. When a steel plate is used, its dimensions must extend past the boundaries of the opening by a minimum of 0.5 inches on all sides or 1 inch over the diameter. The plate must be mounted on the high voltage side of the wall. Example: from the circuit breaker compartment to the instrument compartment, the plate should mount on the circuit breaker compartment side of the wall.

iv. The plate may be welded or bolted in place. SAE grade 5 hardware or better is required for bolting.
Ch 6 Maintenance

A. General

Contact Powell Service Division for assistance in performing maintenance or setting up a maintenance program. E-mail info@powellservice.com or call 1.800.480.7273.

A regular maintenance schedule should be established which obtains the best service and reliability from the switchgear. Plant operating and local conditions will dictate the frequency of inspection required. For specific information regarding the maintenance of devices, removable elements, such as circuit breakers, relays, motors, etc., refer to the separate instruction bulletin furnished with each device. The test cabinet, when furnished, provides a convenient means for maintaining the circuit breakers. Under normal conditions, the protective relays do not operate, therefore, it is important to check the operation of these devices regularly.

A permanent record of all maintenance should be kept, and the degree of detail depends on the operating conditions. In any event, it will be a valuable reference for subsequent maintenance, and for station operation. It is recommended that the record include the reports of tests made, the condition of the equipment, repairs, and any adjustments that were made. Test data from successive maintenance interval should be compared, to note any significant changes in the condition of the switchgear.

⚠️ WARNING

It is essential that the circuit breakers, or circuits be deenergized and the circuit breaker be withdrawn to the disconnected position, and tagged or locked out before any covers are removed, opening of any doors, which permit access to the primary circuits. Any portion of the switchgear that remains energized should be barricaded to prevent accidental access.

⚠️ CAUTION

If maintenance is to be performed on the primary conductors within the switchgear, those conductors should first be grounded, using grounding conductors rated for the short-circuit current rating of the switchgear. A convenient way to ground the primary conductors is by the use of a ground and test device (sometimes referred to as a “ground truck”). Both electrically operated and manually operated versions of the ground and test device, complying with ANSI/IEEE Standard C37.20.2-7.21, are available as optional accessories.

⚠️ CAUTION

If maintenance is to be performed on remote equipment connected to a unit, the circuit breaker for that unit should be placed in the disconnected position, locked out and tagged. Also, the remote equipment should be isolated from any other power sources connected to it.
The primary circuits of metal-clad switchgear are insulated in order to reduce the size of the equipment. However, this insulation, in most instances requires a certain amount of air gap between phases and to ground, which completes the insulation.

**CAUTION**

*Inserting any object in this air space, when energized, whether it be a tool or a part of the body may in effect, short-circuit the air gap and cause a breakdown in the primary circuit to ground and serious damage, injury, or both.*

**B. OVERALL MAINTENANCE PROCEDURES**

The switchgear lineup and connections should be given the following overall maintenance at least once a year:

Powell offers a complete lubrication kit (Powlube-104) which contains all the lubricants required for maintaining Powell equipment. Powlube-104 consists of (1) A-grease, (1) B-grease, and (1) C-oil. Prior to March 2014, Powell provided Powlube-101 and Powlube-102 which contained (1) tube of Anderol 757 or Rheolube 368A, (1) tube of Mobilgrease 28, and (1) bottle of Anderol A456 oil.

A-grease should be lightly applied to those bearing surfaces that are accessible. Inaccessible surfaces, such as bearings, may be lubricated with a light synthetic machine oil such as C-oil. B-grease should be applied to the electrical contact surfaces.

For all previous lubrication requirements Powlube-104, A-grease replaces Anderol 757 and Rheolube 368A, B-grease replaces Mobilgrease 28, and C-oil replaces Mobil 1 and Anderol 456A.

The switchgear lineup and connections should be given the following overall maintenance at least once a year:

1) **Equipment**

Clean the equipment thoroughly, removing all dust and other accumulations. Wipe the buses and supports clean. Refer to *Ch 4 Installation* for cautions about cleaning bus insulation. Inspect the buses and connections carefully for evidence of overheating or weakening of the insulation.

2) **Bus Insulation**

The primary circuit bus bar is insulated with a high temperature thermoplastic or thermoset material that provides dielectric and mechanical properties. Clean the insulation to provide optimum insulation properties.

Only use denatured alcohol or isopropyl alcohol to clean the insulation. Wear protective gloves and goggles and clean the main bus bar in a well ventilated area. Wipe dirt or other foreign matter from the insulation with a clean cloth saturated with only denatured or isopropyl alcohol.

**CAUTION**

*Use alcohol in a well ventilated area to avoid inhaling vapors.*
7) **Secondary Wiring**

Check all wiring connections for tightness including those at the current and potential transformers and at the terminal blocks where the circuits leave the switchgear. Make sure that all secondary wiring connections are properly connected to the switchgear ground bus where indicated.

8) **Mechanical Parts**

Visually check and manually operate the mechanical moving parts such as the shutter, TOC, and MOC mechanism operated cell switch assemblies, the key interlock, hinged doors, and the rollout features of the transformers and fuses. Examine mechanical mating parts such as the circuit breaker racking crank arms and the switchgear guide rails.

9) **Ventilation**

Check all labyrinths, grillwork, and air passages for obstructions and accumulations of dirt. The air space under the outdoor switchgear, which is necessary for the entrance of ventilating air, should be cleaned of leaves and other possible debris. Replace or clean dirty filters.

10) **Battery and Charging Equipment**

The control battery is such an important accessory to the switchgear operation that it must be given special periodic attention if it is to have a long life of reliable service. Periodic inspections and test are recommended in the battery supplier’s instructions. During the same time that the battery is routinely checked, inspect the battery charger and remove any accumulations of dust and dirt.
On all chargers, having a manual transfer switch for setting the charging rate, carefully check and ensure that the selector switch is returned to the value appropriate for a floating charge at the end of the periodic inspection. Serious damage to the control battery can occur if the charger is left on a high charging rate for an extended period of time.

11) Hardware

Check to see all anchor bolts and switchgear hardware are tightened to correct torque values.

12) Heaters

If the switchgear is equipped with anti-condensation heaters, check to see that all heaters are energized and operating properly. This may be done by using a hook-on ammeter to measure the current drawn by the heater.

13) Testing

The condition of each switchgear unit at the time of inspection, should be listed in a permanent record to become a guide for anticipating the need for replacements, or for special attention between the regular maintenance periods.

a. Insulation resistance tests are suggested for checking the insulation. A series of these tests will indicate any tendency towards a reduction in the dielectric strength of the insulation. Insulation resistance readings should be taken before and after cleaning the switchgear equipment, and in so far as possible, under similar conditions at successive periods. Records should include the insulation resistance reading, the temperature, and the humidity (either by definite reading or description).

b. Acceptable limits will vary with the extent and design of the bus structure. In contrast to a small installation, the longer switchgear lineups will have a more extensive bus structure with a greater number of insulators, and thereby, a larger number of parallel insulation resistance paths to ground, which will tend to decrease insulation resistance readings. This variation in insulation resistance between different switchgear lineups emphasizes the value of a series of readings that can be charted to establish a normal insulation level so that progressive weakening of the insulation can be recognized. Voltage transformers and control power transformers should be disconnected during these tests, as they may not be able to withstand the switchgear tests and they may provide direct paths to ground.

c. The resistance of bus connections may be checked by passing a measured DC current of 200A or more, through the joint and measuring the voltage drop (in millivolts) across the joint. An increase in the voltage drop indicates a joint requiring maintenance.

d. Tests on circuit breakers, removable elements, and other devices which are included in the switchgear should be performed in accordance with the instructions applicable to each device.
14) Pressure Vents

Verify that all pressure relief vents are functional and undamaged. Do not walk on pressure vents during inspection. All horizontal vents (top of gear and top of lower breaker/auxiliary compartments) can be accessed from the compartment they cover.

a. Horizontally mounted hinged vents should be checked for free movement around the hinge point. Interference fitting, where two vents are mated over an opening, is acceptable (i.e. the two covers over the circuit breaker compartment may bind slightly on each other as they are closed but they should close completely on to the top of the compartment. Further, they should move freely once clear of each other when opened).

b. Vertically mounted vents should be checked to assure they are still flush to the mounting surface and that no objects could potentially impede opening. Do not attempt to open these vents as they are designed to deform when called upon to operate and are rated for single operation. Attempts to open or otherwise move these vents could damage them. These types of vents should be inspected for damage that would causes them to open partially and potentially expose energized components. Repair or replace as necessary.

15) Doors

Verify that all doors open without interference.

a. The handle should rotate easily to open or close the latch pins. The latch pins should be cleaned and lightly lubricated with A - Grease.

b. The rear frame of the door, including the protruding latch pins should clear the switchgear side door frame without contact. If there is contact, adjust the door in accordance with the instructions in Ch 4 Installation.

c. 3000A doors have a vent system containing a blast cover. Verify that the cover is opened to its fullest extent and that it is free to travel toward the back of the door if pushed.

d. Both front and rear doors should seal with little or no “play” in the fit. Confirm that the latched door has 1/6” or less movement. When the rear door includes a gasket for a weather seal, verify that the gasket is contacted across all mating surfaces by confirming compression marks in the gasket.

e. Exterior doors utilizing tie-down bolts should have gasket material around the tie-down bolt holes. Confirm the presence and functionality of the gasket. If the gasket is damaged, replace it.
16) Interlocks

a. Shutter position interlock front door component - verify that the actuator on the opening side of the door slides freely and operates the shutter position flag. A small amount of A - Grease should be used for lubrication. Close the door and verify the position flag changes from red to green. Rack the circuit breaker slightly toward the connected position and verify that the flag moves from green to red. Verify that the door cannot be opened.

b. Shutter position interlock right side component:
   i. Inspect for wear on latch and spring assembly. Lubricate with A - Grease as necessary.
   ii. Inspect pivot points at top of racking hook and on both glass polyester linkages extending to the shutters for wear.

17) Actuators

Verify alignment of the push-to-trip actuator on the door to the mating actuator on the circuit breaker floor pan. Verify that there is no damage to the sliding actuator on the floor pan and that is slides freely. Lubricate with a small amount of A - Grease if needed.

18) 4000A Versions Only

a. Remove the forced cooled ventilation entry cover (Figure 52, e) below the circuit breaker compartment door and verify that the vent flap (Figure 52, f) behind it is free to move and seals when released.

b. Clean any dust build-up on the forced cooled ventilation exit (Figure 52, a) and fan package (Figure 52, b).

c. Confirm fan operation and proper signal from the alarm switches.

d. Confirm the glass polyester air flow panel (Figure 52, c) above the connected breaker is in place and free to rotate up.

C. Abnormal Conditions

Local conditions such as high ambient temperature, high humidity, salt-laden atmosphere, corrosive gases, heavy dust, ash, severe circuit operating conditions, vermin, or insect problems are considered to be abnormal, and will require more frequent inspections.

A series of inspections should be made at quarterly intervals, until the local conditions can be analyzed to determine a schedule that will maintain the switchgear in satisfactory condition.

In some locations, local conditions may be so bad that the frequency of maintenance will interfere with operating and production schedules. In such cases, consideration should be given to the possibility of enclosing the switchgear lineup in a relatively tight room, and to use filtered air handling units to supply a sufficient quantity of clean air to maintain a positive pressure in the room. Under such conditions, maintenance schedules may then be established on a more normal basis. Such an arrangement might also provide for cooling the air, where the ambient temperature is relatively high, thus further improving operating conditions. To add another level of reliability, chemical filtration may be used in addition to mechanical filtration.
Figure 52  4000A Forced Cooled Section Views

a. Forced Cooled Ventilation Exit  
b. Fan Package  
c. Glass Polyester Air Flow Panel  
d. Circuit Breaker Compartment Door  
e. Forced Cooled Ventilation Entry Cover - 5¼” High  
f. Forced Cooled Ventilation Entry Flap
Ch 7  Recommended Renewal Parts and Replacement Procedures

A. Ordering Instructions

1. Order Renewal Parts from Powell at powellind.com or call 1.800.480.7273.

2. Always specify complete nameplate information, including:
   - Circuit Breaker Type
   - Serial Number
   - Rated Voltage
   - Rated Amps
   - Impulse Withstand
   - Control Voltage (for control devices and coils)

3. Specify the quantity and description of the part and the instruction bulletin number. If the part is in any of the recommended renewal part tables, specify the catalog number. If the part is not in any of the tables, a description should be accompanied by a marked illustration from this instruction bulletin, a photo, or simply submit a sketch showing the part needed.

B. Recommended Renewal Parts

A sufficient amount of renewal parts should be stored to enable the prompt replacement of any worn, broken or damaged part. A sufficient amount of stocked parts minimizes service interruptions caused by breakdowns and saves time and expense. When continuous operation is a primary consideration, a larger quantity of renewal parts should be stocked depending on the severity of the service and the time required to secure replacement parts.

Since parts may be improved periodically, renewal parts may not be identical to the original parts. Table M, Renewal Parts lists the recommended spare parts to be carried in stock by the user with the recommended quantity. As a minimum, it is recommended that one set of parts be stocked per ten circuit breakers or less.

Powell recommends that only qualified technicians perform maintenance on PowlVac-AR® switchgear. Refer to the Qualified Persons section in the front of this instruction bulletin.
### Table M Renewal Parts

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<th>Description</th>
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01.4IB.51200D
PowlVac-AR® Arc Resistant Switchgear

5kV & 15kV
1200A, 2000A, 3000A, & 4000A Forced Cooled

February 2018