01.4IB.51000D
PowlVac® Metal-Clad Switchgear

5kV & 15kV, 1200A, 2000A, 3000A, & 4000A Force Cooled
Contact Information

Powell Electrical Systems, Inc.
powellind.com
info@powellind.com

Service Division
PO Box 12818
Houston, Texas 77217-2818

Tel: 713.944.6900
Fax: 713.948.4569
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, 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® metal-clad switchgear with vacuum circuit breaker:

- 5kV - 1200A, 2000A, 3000A, & 4000A Force Cooled

B. Purpose

The information in this instruction bulletin is intended to provide information required to properly operate and maintain the PowlVac metal-clad 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 metal-clad 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 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.60201A PowlVac® STD Vacuum Circuit Breaker
- 01.4IB.60301A PowlVac® STD 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-enclosed 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® Metal-Clad Switchgear 5kV & 15kV.
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.

D. Specific

1. **DO NOT WORK ON ENERGIZED 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 THE SWITCHGEAR WITH THE CONTROL CIRCUIT ENERGIZED.**

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 SWITCHGEAR.**

E. 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 circuit breaker 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 the actions. Contact the Powell Service Division.

PowlVac® Metal-Clad Switchgear equipped with vacuum circuit breakers is designed to comply with ANSI Standard C37.20.2.

Metal-clad switchgear is characterized by removable interrupting devices, isolation of major circuit elements, grounded metal compartments, and insulated primary bus conductors. The metal-clad switchgear is a line-up of one or more switchgear vertical sections known as units, which are enclosed on all sides, top, and bottom except for the ventilation openings, lower unit cable penetrations, and view windows.

The metal-clad switchgear is used to protect and control medium-voltage/alternating current power distribution systems. Each unit consists of a number of circuit breaker compartments, plus auxiliary compartments containing accessory apparatus. The circuit breakers are used to control various types of circuits, such as incoming lines, bus ties, feeders, and motor starters. Also, special functions are provided in great variety and may be required for particular applications. Figure 1 illustrates a typical PowlVac metal-clad switchgear lineup.

This instruction bulletin should be used in conjunction with the appropriate instructions for vacuum circuit breakers, including any applicable supplement(s), separate instructions covering other components of the metal-clad switchgear, and applicable drawings because each metal-clad switchgear line-up is custom designed for a particular use and application. Separate instructions covering other components are not included in this publication, but are available upon request.
B. **Dimensions**

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

1) **One-high Construction**

The basic one-high construction standard measurements are 92" height x 36" width x 83-5/8" depth. The compartment holds one circuit breaker. For special use, a one-high construction with extended height, front, center, and rear sections is available.

![Figure 2 One High Basic Construction](image1)

2) **Two-high Construction**

The two-high basic construction standard measurements are 95" height x 36" width x 95-1/8" depth. This construction can hold two circuit breakers; one in each compartment located one above the other.

![Figure 3 Two-High Basic Construction](image2)

Note: Each construction includes primary and secondary compartments, as shown in Figure 2 and 3. These instructions apply to both types of construction. Where significant differences exist between the two construction types, each is explained separately.

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 enclosure contains control devices, current transformers, shutters, interlocks, and a ground bus. See Figure 3 for the location of the primary enclosure and see Figure 4 for the equipment's devices.
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 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 passageway 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 are vertical passageways between the secondary compartments and the lower primary compartments.

### 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>
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<tbody>
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<td>1200, 2000</td>
<td>25, 36, 50 &amp; 63</td>
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<td>83(\frac{3}{8})</td>
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<tr>
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<td>1200, 2000, 3000</td>
<td>25, 36, 50 &amp; 63</td>
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<tr>
<td>One-High</td>
<td>4000 (FC)*</td>
<td>25, 36, 50 &amp; 63</td>
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<td>Two-High</td>
<td>1200, 2000</td>
<td>25, 36, 50 &amp; 63</td>
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**Note:** *Force Cooled*
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<th>Maximum Voltage</th>
<th>Nominal Voltage</th>
<th>Power Frequency Withstand (kV)</th>
<th>BIL Crest (kV)</th>
<th>Main Bus Continuous Current (A rms)</th>
<th>Symmetrical short-circuit Rating (kA rms)</th>
<th>Short Time Current 2 sec. (kA)</th>
<th>Momentary withstand Rating (kA Crest)</th>
<th>Obsolete MVA Rating</th>
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<td>19</td>
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7.2kV-15kV

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<th>Nominal Voltage</th>
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<th>BIL Crest (kV)</th>
<th>Main Bus Continuous Current (A rms)</th>
<th>Symmetrical Interrupting Rating (kA rms)</th>
<th>Short Time Current 3 sec. (kA)</th>
<th>Momentary withstand Rating (kA Crest)</th>
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E. Ratings

Ratings of PowlVac® switchgear and circuit breakers are based on factors supplied in the following:

- ANSI C37.04 Circuit Breaker Rating Structure
- ANSI C37.06 Circuit Breaker Ratings
- ANSI C37.20.2 Switchgear Assemblies

See Table B, Ratings of Medium Voltage PowlVac® Metal-Clad Switchgear for complete ratings.

Note: Certain non-standard ratings are available for special applications. Consult the manufacturer for details. Refer to the specific job drawings for detailed voltage ratings applicable to particular switchgear line-up.

F. Lighting Impulse Withstand (BIL)

The basic impulse level is 60kV for the 4.16kV class switchgear and 95kV for the 7.2kV and 13.8kV class switchgear. The basic impulse level testing excludes control transformers, starting reactors, and autotransformers.

Note: If required, Field Dielectric Tests should be limited to 75% of Factory Dielectric Test values. Direct current dielectric testing is not recommended. If DC testing is required, see Ch 5 Operation, O. Test and Inspection for values to be used.
Equipment Description

01.4IB.51000DPowlVac® Metal-Clad Switchgear
5kV & 15kV

Figure 4  Interior Metal-Clad Switchgear (Lower Compartment)

a. Mechanism-Operated Cell Switch (MOC)
b. Position Interlocks (optional)
c. Current Transformer
d. MOC Operating Mechanism
e. Breaker Enclosure Interference Plate
f. Floor Pan
g. Truck-Operated Cell Switch (TOC)
h. Shutters
i. Shutter Operating Mechanism
j. Secondary Disconnect Plug
k. Ground Bus
l. Rollout Stop Block

G. CIRCUIT BREAKERS

PowlVac® 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 with equal ratings are interchangeable.

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

Figure 5  Front Cover of Circuit Breaker

a. Cover Bolts
b. Front Cover
c. Breaker Position Indicator
d. Racking Drive Shaft Shutter
e. Nameplate
f. Padlock Provision - Stationary Clip
g. Padlock Provision - Movable Arm
h. Manual Trip Operator
i. Handle
j. Manual Charging Crank
k. MOC Actuator
l. Circuit Breaker Open/Closed Indicator
m. Secondary Disconnect Receptacle
n. Manual Close Operator
o. Operations Counter
p. Secondary Disconnect Latch
q. Spring Charge Indicator

Note: Image shown is PowlVac STD Vacuum Circuit Breaker Front View with Cover.
H. **Circuit Breaker Racking Mechanism**

- **NOTICE**

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

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.

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 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.

- **NOTICE**

*When 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.*
I. Safety Interlocks and Provisions

**NOTICE**

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

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.

**NOTICE**

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 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. If equipped with a CDR circuit breaker, 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 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.

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.

**Figure 6  Circuit Breaker Cover Removed**

a. TOC Actuator  
b. Opening Spring  
c. Main Closing Spring  
d. MOC Actuator  
e. Charging Motor

**J. Auxiliary Compartments**

Many sizes of auxiliary enclosures and compartments are furnished for various purposes in PowlVac® Metal-clad Switchgear line-ups. Some are listed below:

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

**K. Anti-Condensation Heaters**

Anti-condensation heaters are provided in all PowlVac switchgear in order to facilitate drying and to 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. See **Figure 7**.

Heaters in circuit breaker compartments are located on the bottom right 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.

**Figure 7  Unit Space Heater**
L. **VOLTAGE (POTENTIAL) TRANSFORMER (ROLLOUT CARRIAGE)**

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 striking distance from all live parts of the metal-clad 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. See Figure 8. When the voltage transformer rollout tray is in the disconnected position, the rear barrier of the tray effectively deters access to the stationary primary disconnects mounted in the compartment behind the rollout tray. However, these stationary primary disconnects may remain energized.

M. **FUSE DISCONNECTING DEVICE (ROLLOUT CARRIAGE)**

Current limiting fuses with high interrupting rating are sometimes used in metal-clad switchgear to protect small transformers or circuits where circuit breakers cannot be economically or functionally justified.

The fuses are mounted on a rollout tray equipped with disconnecting devices. Control power transformers of 15kVA and smaller may be mounted on the rollout with the fuses. See Figure 9.

---

**WARNING**

Do not remove the rollout tray from its rails without first deenergizing the primary circuit to which the roll-out connects. Removing the tray makes the stationary primary disconnect devices accessible.
When fuses are disconnected, they are at a safe striking distance from all live parts of the switchgear. In addition, a grounding device is provided which contacts the fuses after they are disconnected, effectively removing any static charge from the fuses. In this position, the fuses may be safely removed and replaced. The primary disconnecting devices are capable of interrupting transformer magnetizing current, but should not be used to interrupt load current. Mechanical or key interlocks are applied to prevent operating the disconnecting device while the load is connected. This is generally accomplished by interlocking so that the transformer secondary breaker must be locked in the open position before the rollout carriage can be moved to connect or disconnect the primary disconnect device in the switchgear.

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.

**N. CURRENT TRANSFORMERS (THROUGH-TYPE)**

Ring-type current transformers *(Figure 4, c)* are positioned around the stationary primary disconnect devices. These current transformers are removable from the front and may be located on upper and/or lower primary disconnect supports. When necessary, special current transformers may be mounted in the line module.

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**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.*

---

**O. MAIN BUS, MAIN BUS TAPS, AND GROUNDS**

The main bus, main bus taps, and ground bus conductors are made of copper. 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 bolted connections are silver-plated or tin-plated.

The main bus supports of a 15kV class metal-clad switchgear are of molded epoxy. The main bus supports of a 5kV class metal-clad switchgear are of polyester laminate.
P. PRIMARY DISCONNECT DEVICES AND SUPPORTS

The stationary primary disconnect devices have 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 disconnects 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 \( \frac{1}{8} \) inch.

Q. LIGHTING

For through-door and closed-door racking, all metal-clad switchgear are equipped with a 120VAC interior light 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 email 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 metal-clad 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. See Table C, Bolt Torque Values for PowlVac® Metal-Clad Switchgear.

B. Receiving

PowlVac 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 will 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

It is always preferable to handle a PowlVac metal-clad switchgear line-up with overhead cranes, by the lifting means provided on the switchgear. See Figure 10.

For an outdoor switchgear line-up, lifting channels are provided and are attached to the base of the vertical sections. Spreaders should be used in the slings above the vertical sections to prevent damage to the top edges of the switchgear. Do not attempt to lift the switchgear by using the angles installed on the sides. The angles are provided only to tie the vertical sections down during shipment, which ensures that the unit will not tip over if it is top-heavy. The angles are not to be used for lifting purposes. Slings should be tied to referenced angles to prevent equipment tipping.
If bases are furnished, the switchgear may be moved on an even surface by the use of rollers or heavy-duty pipes placed under the base. Any force to move or jack the switchgear must be applied to the base and not to the switchgear. The use of a forklift truck is not recommended, since the forks may damage the compartments or interior parts of the switchgear vertical sections. If no other method of handling is available, the forks must go completely under the switchgear base bottom to avoid damage to the switchgear.

**Figure 10  Lifting Method for Switchgear**

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, if so equipped. 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 remain rigid and not sag under the weight of the switchgear structure. The floor also must be able to withstand the impact stress caused by the opening of the circuit breakers under short-circuit conditions. The short circuit impact load is approximately 1-1/2 times the static load weight of the switchgear.

The purchaser must provide suitable means for anchoring the switchgear to the floor. The floor supporting the switchgear must be level in order to avoid distorting the switchgear structure and to align the switchgear properly. The switchgear must be correctly and completely aligned prior to applying final anchors. Level foundations are desirable since they automatically produce true, level, and plumb switchboard installations. However, the switchgear will operate satisfactorily on a true and flat foundation that has a uniform slope of no more than 1/8 inch in three feet. The switchgear units must be placed on the floor channels in such a manner that the base of each unit rests directly on each of the floor channels. The recommended floor construction is shown in Figure 11.

The floor channels should have a minimum web dimension of 4 inches. The required quantity and location of the floor channels is shown on the drawings furnished with the order. The spacing of the floor channels, including the center channel, must be as shown on the drawings. Even though the switchgear is not anchored to the center channel, its location is important to the proper support and alignment of the switchgear units. The floor channels must be level and straight with respect to each other. Brass shims should be placed under floor channels when leveling is needed.

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 should be no more than the two metal thicknesses that make up the compartment floor and breaker pan. 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 1/4”.

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 recommended practice 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 should be painted to deter corrosion. If welding facilities are not available, the switchgear should be bolted to the floor channels.

**Figure 11 Recommended Floor**

![Recommended Method](image)

F. **Positioning the Metal-Clad Switchgear**

1) **Drawings and Diagrams**

Before any installation work is done, consult and study all drawings and the Bill of Materials furnished by Powell for the particular order. The drawings include arrangement drawings and wiring and schematic diagrams.

The recommended aisle space for the front and at the rear of the metal-clad 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 roll out voltage or control power transformers. The dimensions shown on the switchgear drawings are those required for proper operation of the switchgear.

When three or more switchgear units are to be arranged in one continuous line-up, the center shipping unit should be the first located. The other shipping line-ups 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 metal-clad switchgear line-up 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.

Establish a base line located a few inches in front of the units and parallel with the desired front of the structure. Equalize the distances from the front of the units to the base line to make the face of the group parallel to the base line.

**NOTICE**

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.
Additional shipping members may have been installed in the bus or primary area to ensure against shipping damage. All shipping members must be removed from the switchgear compartments. All joints must be properly tightened and insulated before energizing the bus.

Mats, screens, railing, etc. that are external to metal-clad switchgear may be required to meet local code. These items must be provided by the purchaser.

**Figure 12  Anchoring of Units with Channel Base**

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. Doors may be raised or lowered vertically, moved left or right horizontally, or rotated to plumb 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. See Table C, Bolt Torque Values for proper torque values.
4. If the doors require further alignment, additional adjustments may be made to the stationary half of the hinge assembly, which is mounted by screws, located inside the flange of the switchgear side sheet. When properly aligned, the doors of outdoor switchgear should be tightly seated on the gasket all around the closure. After aligning doors, close and latch the door and check the seal by inspecting the gasket for impression or by running a 3” x 5” card around the edge of the door. If the card passes between the door and the gasket, the door is improperly adjusted, and it should be realigned until the card cannot pass between the door and the gasket.
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 in the switchgear, it will be locked in place by a special bracket designed to prevent motion during shipment. This bracket must be removed and discarded in order to move the circuit breaker (Figure 13, a).

Figure 13 Circuit Breaker with Shipping Bracket

Prior to inserting a removable element into the compartment, manually check the shutter mechanism, the mechanism-operated cell (MOC) switch and operating mechanism, and the truck-operated cell (TOC) switch for free movement. These checks shall be made with all circuits deenergized.

Figure 14 Auxiliary Device with Shipping Bracket

CAUTION

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, S. 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.

A ground bus is furnished with lugs at each end for connection to the station grounding system.

The ground is bolted to the rear of the vertical section near the bottom. It is arranged so that connections to the station ground can be made in any unit. Where equipment is shipped in more than one group, the sections of ground bus must be connected by using the splice plates furnished with the equipment.

Assemble the ground bus joints as outlined in Ch 4 Installation, J. Connections. The switchgear ground bus must be connected to the station ground bus by a conductor having a current carrying capacity equal to that of the switchgear ground bus. It is very important that the equipment be adequately grounded to protect the operator from injury if short circuits or other abnormal occurrences take place and to ensure that all parts of the equipment, other than live parts, are at ground potential.

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. 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.

**WARNING**

*Ensure that the switchgear vertical sections are grounded prior to making power connections, if they are not it could result in death or serious injury.*
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 15 for proper assembly of hardware.

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, K. Main Bus Assembly and Insulation.

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

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</tr>
<tr>
<td>1/2</td>
<td>![Image]</td>
<td>35-50, 4.8-6.9</td>
</tr>
<tr>
<td>3/8</td>
<td>![Image]</td>
<td>20-30, 2.8-4.2</td>
</tr>
<tr>
<td>1/4</td>
<td>![Image]</td>
<td>5-7, 0.7-0.97</td>
</tr>
</tbody>
</table>

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

#### 1) Main Bus Joint Insulation

Main bus joints are insulated with either a custom fitted boot or with hand applied insulating tape. *Ch 4 Installation, K. Main Bus Assembly and Insulation*

*2) Wrapping of Joints* will describe the procedure for hand applied insulating tape wrapped joints. After installing main bus conductors the joints must be insulated as follows.

a. Tighten the bus bar splice plate bolts properly. See *Table C 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 16).*

#### Figure 16  Placing the Boot over the Joint

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

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.*

**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.

c. Align holes of each side of the boot.

d. Thread tie wraps through the holes and pull tight, creating a seal *(Figure 17, a).*

e. An alternative method of assembly uses push rivets *(Figure 17, b).* Push the rivets completely through on both sides of the boot. Verify the edges of the boot seal.
Figure 17  Boot Installation

a. Pull tie wrap tight to seal boot
b. Press rivet to seal boot

2) Wrapping of Joints

The following insulation system involves the use of high voltage insulating tape and electrical grade rubber-based (RB) 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>Table D Bus Wrapping Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number</td>
</tr>
<tr>
<td>0282A3529P004</td>
</tr>
<tr>
<td>0282A3529P005</td>
</tr>
<tr>
<td>0282A3529P008</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.

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”x1⅛” and 0.030”x4” stretches and reduces to approximately 0.024”x3½”.
Table E Insulation of Bus Bar

<table>
<thead>
<tr>
<th>Insulation Range (volts)</th>
<th>Number of Layers</th>
<th>Tape Width (inches)</th>
<th>Tape Footage Required to Insulate (1) Linear Foot of Bus Bar (2&quot; &amp; 4&quot; Wide Rolls are 30' Long)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600V to 5000V</td>
<td>1 Layer - 1/2 Lap *</td>
<td>2/4 3/4 5/6 8/9 11/12</td>
<td>1/4 x 2 1/3 x 3 1/2 x 3 1/4 x 4 1/5 x 4 1/6 x 4 1/7 x 6 1/8 x 6 1/9 x 6 1/10 x 6 1/15 x 6</td>
</tr>
<tr>
<td>5000V to 15000V</td>
<td>2 Layer - 1/2 Lap *</td>
<td>2/4 5/6 8/9 11/12</td>
<td>1/4 x 2 1/3 x 3 1/2 x 3 1/4 x 4 1/5 x 4 1/6 x 4 1/7 x 6 1/8 x 6 1/9 x 6 1/10 x 6 1/15 x 6</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"x1 3/4" and 0.030"x4" down to 0.024"x3 1/2". Apply with mastic side down.

*Apply 3 layers - 1/2 lap for conductors passing through CT's.*

Table F Insulation of Single Bus Bar Connection Joint

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler</th>
<th>Outer Wrap</th>
<th>“C” (inches)</th>
<th>Approx. Number 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>1 Roll HV Tape</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 1 ½” x 5’ long.

*High voltage insulating tape 0282A3529P004 - Roll is .030 x 2” x 30’ long. Apply with mastic side down.*
**Figure 20 Double Bus Bar Connection Joint**

- 4" (101.6) Wide PAD HV Tape #
- RB Putty *
- Framework

**Table G 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 of 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 #</td>
<td>2 Layers HV Tape Δ</td>
<td>3</td>
<td>½ Roll RB Putty *</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.

# HV Tape 0282A3529P005 roll is .030” x 4” x 30’ long.

Δ HV Tape 0282A3529P004 roll is .030” x 2” x 30’ long. Apply with mastic side down.

**Figure 21 Tee Connection Joint**

- Epoxy Insulation Thermoplastic Sleeving or Tape Insulation
- Overlap Tape in a Figure Eight Pattern
- RB Putty *

**Table H 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 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>
</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 $\frac{1}{8}” \times 1 \frac{1}{2}” \times 5’$ long.

Δ HV Tape 0282A3529P004 roll is .030” x 2” x 30’ long. Apply with mastic side down.
3) **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.

4) **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.

5) **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 clean the bus by blowing with compressed air. Dust and dirt removed in this manner may be blown into operating parts of the switchgear and damage bearings or other mechanisms.

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.

**L. PRIMARY CABLES**

Access the primary cable connections in PowlVac® Metal-Clad Switchgear 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 cables. 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. In all cases, carefully follow the cable manufacturer's recommendations for installation of the type of cable being used. Normally, no insulation or stress relief materials are 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.
M. 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 cable termination joints should be insulated as outlined Figure 22.
2. All taping of roof bushing should be insulated as shown in Figure 24. See Ch 4 Installation, Q. Roof Entrance Bushing for details.

2. The instructions for application of the tape insulation are the same as outlined for wrapping of joints. See Ch 4 Installation, K. Main Bus Assembly and Insulation, 2) Wrapping of Joints.

![Figure 22 Cable Termination Joint](image)

Table I Cable Termination 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. No. of 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>1 Roll Putty* &amp; 2 Roll Tape Δ</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 \( \frac{1}{8} \text{”} \times 1\frac{1}{2} \text{”} \times 5 \text{’ long} \)

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

---

**Figure 23** Bar-Type Current Transformer Joint Insulation

![Diagram of Bar-Type Current Transformer Joint](image)

**Table J 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 ‡</td>
<td>½ Roll HV Tape ∆</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1½ Roll HV Tape ∆</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.

∆ HV Tape 0282A3529P004 roll is .030" x 2" x 30' long. Apply with mastic side down.

---
O. CONTROL CABLES

Space is provided for control cables to enter the switchgear from either the top or the bottom of the units. See drawings furnished with the switchgear for detailed dimensions and location of the control cable entry space.

When control conduits enter the unit from below, entry space is located on each side of the unit near the front inside the secondary enclosure. 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, whichever is more convenient. However, if the cables are pulled before the switchgear is installed, they must be threaded through the opening in the switchgear floor plate when setting the switchgear in place.

All control wiring that passes through an area designated as high voltage (part of the primary circuit) must be shielded or run through a wireway to maintain the metal-clad isolation requirements.

Connect the cables to the terminal blocks in accordance with the wiring diagrams furnished for the specific job.

If the control conduits enter from above, drill the top cover plate of the front enclosure to suit the conduits, being careful not to damage existing wire bundles. The top cover may be removed temporarily to facilitate drilling. Fasten the conduits to the cover with locknuts.

The cables from the control power source to the switchgear should 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.

P. SURGE PROTECTION

It will be 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.

Q. 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 electrical grade rubber-based putty, refer to Table D, Bus Wrapping Components. 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 24. Where there are sharp angles, apply additional layers to obtain equivalent of the insulation on the flat surfaces.

### Figure 24  Roof Bushing

![Figure 24 Roof Bushing](image)

#### Table K Pothead, Bushing, or Terminator

<table>
<thead>
<tr>
<th>Insulation Level (kV)</th>
<th>Inner Filler “A”</th>
<th>Outer Wrap “B”</th>
<th>“C” (inches)</th>
<th>Approx. No. of 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>1 Roll Putty* &amp; 2 Roll Tape Δ</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 1/8” x 1 1/2” x 5’ long

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

### R. Bus Duct Entry

Bus duct entry into the switchgear must maintain metal-clad switchgear isolation and integrity. Connections to the bus are made from the outside of the equipment as is typical with standard bus duct.
S. **AUXILIARY DEVICE ROLLOUT CARRIAGE**

Rollout carriages will be shipped in a slightly open position, which are held in place by two angle shipping brackets bolted to the left and right support plates.

Remove and discard the brackets and the hardware, which are used to attach them to the support plates *(Figure 25, a).*

*Figure 25 Angle Shipping Bracket*

![Angle Shipping Bracket](image)

To close the carriage, operate the secondary circuit breaker to the “off” position, lower the interlock slider, and turn the “T” handle counterclockwise. It should not be possible to close the secondary circuit breaker with the interlock in this position. Close the carriage in a smooth but brisk motion, and turn the “T” handle clockwise raising the interlock slider, and operate the secondary circuit breaker to the “on” position. With the interlock in this position, it should not be possible to turn the “T” handle counterclockwise far enough to unlatch the carriage, or to roll out the carriage.

To open the carriage, reverse the above procedure, withdrawing the carriage in a smooth but brisk motion, to prevent arcing between the contacts.

2) **Fuse Rollout**

Fuse rollouts are normally interlocked with the secondary circuit breaker of the transformer that the fuses protect, using a key interlock system. The secondary circuit breaker is provided with a key interlock which releases a key only when the circuit breaker is locked in the “off” position. The rollout carriage is provided with a key interlock, which deter opening or closing of the carriage unless the key is retained and the bolt is withdrawn.
Ch 5 Operation

A. GENERAL

All removable elements, such as the circuit breakers 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 different 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.

B. INSERTING THE REMOVABLE ELEMENT INTO THE COMPARTMENT

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 moveable primary disconnects. Otherwise, the primary disconnects, shutters, or the racking mechanisms may be damaged.

Do not place the circuit breaker into the compartment until the switchgear lineup installation is complete. If the circuit breakers are placed into the switchgear lineup before the installation is complete, trouble may occur from foreign materials in the compartments and from a non-level foundation or from distortion caused during shipment or handling.

The circuit breaker may be inserted into the lower compartment of the switchgear by first aligning the circuit breaker wheels with the compartment floor pan channels. The circuit breaker is now ready to be inserted into the test position, and then racked to the connected position. Refer to the applicable circuit breaker instruction bulletin for more detailed instructions to perform this operation.

The procedure for inserting a circuit breaker into the upper compartment of a two-high construction varies based on the design of the lift truck that is used.
The standard lift truck is used when adequate aisle space (68” minimum) is available. Perform the following steps to insert a circuit breaker in the upper compartment:

1) **Inserting the Circuit Breaker Into the Lower Compartment (One-High Design)**

   Use the appropriate circuit breaker or ground and test device instruction bulletin in conjunction with this section to insert/remove the element from the switchgear compartment.

   a. Verify that the circuit breaker open/closed indicator displays “BREAKER OPEN” and if not, press the manual trip operator to open the circuit breaker.

   b. To insert the circuit breaker into the lower circuit breaker compartment, open the compartment door and align the wheels with the floor pan channels of the compartment. Verify that there are no locks or tags on the circuit breaker of the shutter interlock that would block operation or indicate an issue with the equipment and that the floor pan channels are free of debris prior to inserting the circuit breaker.

   c. Roll the circuit breaker in the compartment until the racking crank arms make contact with the vertical slots in the compartment. The anti-rollout latch on the lower right side of the circuit breaker will engage the block in the compartment, preventing accidental removal of the circuit breaker from the compartment.

   **Note:** *This is the disconnected position.*

2) **Inserting the Circuit Breaker Into the Upper Compartment (Two-High Design)**

   Use the appropriate circuit breaker or ground and test device instruction bulletin in conjunction with this section to insert/remove the element from the switchgear compartment.

   a. Verify that the circuit breaker open/closed indicator displays “BREAKER OPEN” and if not, press the manual trip operator to open the circuit breaker. Verify that there are no locks or tags on the circuit breaker or the shutter interlock that would block operation or indicate an issue with the equipment and that the floor pan channels are free of debris prior to inserting the circuit breaker.

   b. To insert the circuit breaker into the upper circuit breaker compartment a lifting device is required (Figure 26). If the aisle spacing is adequate, the standard lift truck may be used (68” of space is required). See Table N, Lift Trucks for specifications.

   c. Lower the lift truck tray to the ground and roll the circuit breaker onto the tray until the anti-rollout latch engages with the ramp on the tray (Figure 26, b).

   d. Open the circuit breaker compartment door and align the truck with the opening. Raise the tray until the front of the tray is slightly higher than the front edge of the compartment (Figure 26, e).

   e. Move the lift truck forward and align the tabs on the front of the tray with the cutouts in the circuit breaker compartment (Figure 26, f). Lower the tray until the tabs set in the cutouts. Apply the brake on the lift truck.
f. Roll the circuit breaker in the compartment until the racking crank arms make contact with the vertical slots in the compartment. The anti-rollout latch on the lower right side of the circuit breaker will engage the block in the compartment, preventing accidental removal of the circuit breaker from the compartment.

Note: This is the disconnected position.

g. Raise the tray of the lift truck to clear the front edge of the compartment, release the lift truck brake and move the truck away from the compartment. Lower the tray and return the truck to its storage point.

For removal of the circuit breaker, refer to the applicable circuit breaker instruction bulletin.

Note: An alternate lift truck may be used for a switchgear line-up that has an aisle space as narrow as 60 inches.

C. Racking Mechanism

The racking mechanism consists of two slotted cam plates mounted on each side of the compartment (Figure 36, 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 procedures that move the circuit breaker from one position to another are known as “standard racking”, “closed door racking”, “through door racking”, and “power racking”. Closed door racking, through door racking, and power racking are the three optional methods for racking the circuit breaker into the compartment. All three racking methods incorporate a torque limiting device which prevents damage to the racking mechanism. Refer to appropriate instructions for PowlVac® Vacuum Circuit Breakers, including any applicable supplement(s), for a further description of the full operating instructions for this racking mechanism.

⚠️ CAUTION

This is a two (2) person job. Do not attempt to perform this procedure alone, as it may result in injury to the user, damage to the circuit breaker, or damage to the lift truck.

⚠️ CAUTION

When removing the circuit breaker from the lift truck, hold the lift truck firmly in place to prevent the truck from rolling away from the circuit breaker.
Figure 26  Recommended Method for Lifting Circuit Breaker to Upper Cell

a. Lift Truck Ready to receive the Circuit Breaker
b. Circuit Breaker placed on the Lift Truck
c. Circuit Breaker latched in the Lift Truck tray

b. Lift Truck and Switchgear Position
e. Circuit Breaker approaching hook
f. Circuit Breaker rolled into the compartment
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.

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.

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.

With the three optional methods of racking, the front door of the compartment has an opening, which enables the racking procedure to be performed. This opening is covered by a teardrop cover which automatically closes by gravity when the racking handle is removed. The metal-clad switchgear door is also provided with other options, such as a viewing window, and an internal light which will allow viewing the breaker position indicator (Figure 5, c) located on the circuit breaker to be viewed.

A further option to closed door racking is closed door tripping. If this option is furnished, a mechanical trip button on the door operates a mechanism within the compartment, which trips the removable element.
D. Racking Procedure (Manual)

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 moveable primary disconnects. Otherwise, the primary disconnects, shutters, or the racking mechanisms may be damaged.

CAUTION

Prior to inserting the circuit breaker into the circuit breaker compartment, make sure that the control circuits are deenergized.

1) Inserting the Circuit Breaker to the Test/Disconnected Position

a. Verify that the circuit breaker open/closed indicator displays “BREAKER OPEN” and if not, press the manual trip operator to open the circuit breaker.
b. To insert the circuit breaker into the lower circuit breaker compartment, open the compartment door and align the wheels with the floor pan channels of the compartment. Verify that the floor pan channels are free of debris prior to inserting the circuit breaker.
c. Roll the circuit breaker in the compartment until the racking crank arms make contact with the vertical slots in the compartment. The anti-rollout latch on the lower right side of the circuit breaker will engage the block in the compartment, preventing accidental removal of the circuit breaker from the compartment.

d. Insert the circuit breaker compartment secondary disconnect plug into the circuit breaker secondary disconnect receptacle (Figure 28). Be sure to insert the plug fully and ascertain that the secondary disconnect latch, located just below the secondary disconnect interlock, has engaged the pin on the interlock bar.

Note: This is the Test Position.

Note: This is the Disconnected Position.
2) **Inserting the Circuit Breaker to the Connected Position**

   a. Press and hold the manual trip operator and simultaneously open the racking drive shaft shutter *(Figure 30)*. Place the racking handle socket onto the racking drive shaft. The racking handle socket may be used to push down the shutter to gain access to the racking drive shaft.

   b. Release the manual trip operator. It will remain actuated as long as the shutter is held open by the racking handle socket.

   **Figure 30  Pushing Manual Trip Operator & Accessing Racking Drive Shaft**

   c. Turning the racking handle clockwise will begin to rack the circuit breaker into the compartment *(Figure 31)*. When the circuit breaker is racked into the compartment, the force needed to rotate the racking handle will be low at the beginning of motion as the movement of the racking crank arms is only opening the shutters. Once the shutters are open, the circuit breaker begins to move toward the stationary primary disconnecting devices. When the movable primary disconnecting devices of the circuit breaker engage the stationary primary disconnecting devices of the compartment, the force required to rotate the racking handle will increase appreciably. This force will decrease as the primary disconnecting devices spread and engage fully. Continuing rotation of the racking handle will cause the circuit breaker to travel further into the compartment ensuring wipe or overlap of the primary disconnecting devices. Continue racking until the breaker position indicator displays "**BREAKER CONNECTED**": This will be approximately 22 rotations from the starting point. When the circuit breaker reaches the end of the racking travel, the user will notice an increased amount of force. If the operator continues to apply force, a torque limiter on the racking handle will produce a sharp clicking sound indicating the torque limit is reached at 35 -ft-lb. Should the operator continue to apply force, the torque limiter will continue to operate with no further buildup of torque on the circuit breaker mechanism.
d. Once the circuit breaker has reached the connected position, remove the racking handle, verify that the manual trip operator has returned to its normal position, close the compartment door, and operate the circuit breaker as required.

**Note:** This is the Connected Position.

3) Removing the Circuit Breaker from the Connected Position

**CAUTION**

Prior to removing the circuit breaker from the circuit breaker compartment, make sure that the control circuits are deenergized.

**CAUTION**

Prior to removing the circuit breaker from the circuit breaker compartment, make sure the circuit breaker is in the open position and all springs are discharged.

a. Verify that the circuit breaker open/closed indicator displays "BREAKER OPEN". If "CLOSED", close door and open breaker from a remote location or alternately by using the circuit breaker control switch on compartment door. Open door and verify that the circuit breaker open/closed indicator displays "BREAKER OPEN".

b. With the compartment door open, press and hold the manual trip operator and simultaneously open the racking drive shaft shutter. Place the racking handle socket onto the racking drive shaft shutter. The racking handle socket may be used to push down the shutter to gain access to the racking drive shaft.

c. Release the manual trip operator. It will remain actuated as long as the shutter is held open by the racking handle socket.
d. Turn the racking handle counterclockwise until the breaker position indicator displays “BREAKER TEST/DISCONNECTED”.
e. Remove the racking handle and verify that the manual trip operator has returned to its normal position.

**Note:** This is the Test Position.

4) Removing the Circuit Breaker from the Test/Disconnected Position out of the Circuit Breaker Compartment

**CAUTION**

Prior to removing the circuit breaker from the circuit breaker compartment, make sure that the control circuits are deenergized.

**CAUTION**

Prior to removing the circuit breaker from the circuit breaker compartment, make sure the circuit breaker is in the open position and all springs are discharged.

a. Open the circuit breaker compartment door.
b. Press down on the secondary disconnect latch (Figure 28, d) and remove the circuit breaker compartment secondary disconnect plug (Figure 28, c). Store the plug so it will not be damaged while withdrawing the circuit breaker.

**Note:** Removing the secondary disconnect plug will trip a closed breaker and discharge the main closing spring.

c. Press the anti-rollout latch (Figure 32, a) to release the circuit breaker and pull the circuit breaker out of the circuit breaker compartment using the handles.

**Figure 32** Anti-Rollout Latch

**E. Racking Procedure (Electrical)**

This is an alternative to the manual racking procedures described above 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. **Electrical Operation**

1. A one-line, or three-line diagram, and a schematic diagram are prepared for each metal-clad switchgear line-up. All diagrams shall be thoroughly studied and completely understood by the user before the metal-clad 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 synchronism 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.

G. **Shutters**

Metal shutters (Figure 33, a) cover the primary disconnect contacts when the removable element is withdrawn from the compartment.

![Figure 33 Shutters](image)

Cam plates (Figure 36, c) located on each side of the compartment are operated by the circuit breaker crank arm rollers, which will then operate the switchgear shutters. As the circuit breaker is operated past the disconnected position, the crank arm rollers will move the cam plates rearward, 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. Padlocking either of the two cam plates will deter opening of the shutters.
H. Removable Element Position Interlock (Optional)

**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.*

The removable element position 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 lock provisions. See Figure 34.

**Figure 34 Position Interlock**

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. The L-shaped bar of the key interlock is attached to a steel plate which blocks movement of the removable element. There are two varieties of the steel plate. When the first variety is used, it blocks the operation of the key interlock when a removable element is in the connected position.

This prevents locking the removable element in the connected position, giving the interlock a “lock out only” function. The second variety of steel plate enables the interlock to be operated with the removable element in either the connected or disconnected position, which gives the interlock a “lock in and out” function.

I. Floor Pan

Each compartment is equipped with a floor pan (*Figure 4, f*), which the removable element rolls on. Each side of the pan is designed with channels, which the wheels of the removable element roll 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. The latch deters the removal of the removable element until the latch is manually de-pressed.
J. **Truck-Operated Cell Switch (TOC) (Optional)**

The purpose of the truck-operated cell switch (TOC) (Figure 4, g) 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 actuator (Figure 6, a) 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.

![Figure 35 Typical Compartment Door with Closed Door or Through-Door Provisions](image)

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

The mechanism-operated cell switch (MOC) is an auxiliary switch operated by linkages in the compartment, which operates in conjunction with the circuit breaker mechanism.

The MOC switch operating arm, which projects from the jackshaft of the circuit breaker at the lower left side of the circuit breaker, operates in conjunction with the MOC assembly. This arm 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 to the switch connects the angle, and the assembly is spring-loaded to the open position. In the one-high basic construction and in the lower compartments of the two-high basic construction, the switch is mounted in the compartment near the upper left corner, and the operating linkage extends downward to the pivoted angle. In the upper compartments of the two-high construction, the switch is mounted below the left side of the circuit breaker, and the operating linkage extends upward to the pivoted angle. See Figure 36 and Figure 37. As supplied, the mechanism-operated cell switch (MOC) 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.
L. **Secondary Disconnect Device**

The switchgear has a secondary disconnect device, which is a plug mounted at the lower end of an umbilical cord, which hangs at the right side of the compartment. The secondary disconnect plug (*Figure 4, j*) plugs into the secondary disconnect receptacle (*Figure 5, m*) on the lower right front of the circuit breaker.

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

1. The secondary disconnect plug must be inserted into the secondary disconnect receptacle when the circuit breaker is in the disconnect 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’s 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.

*Figure 36* Lower Mechanism-Operated Cell Switch (MOC) and Operating Mechanism

a. Mechanism-Operated Cell Switch (MOC)
b. MOC Operating Linkage
c. Cam Plate
d. Shutter Operating Cam Plate
e. Pivoted MOC Operating Angle
f. Bolted-On Angle
Figure 37  
Upper Mechanism-Operated Cell Switch (MOC) and Operating Mechanism

- a. Mechanism-Operated Cell Switch (MOC)
- b. MOC Operating Linkage
- c. Cam Plate
- d. Shutter Operating Cam Plate
- e. Pivoted MOC Operating Angle
- f. Bolted-on Angle

M. Dummy Removable Element

Dummy removable elements are used as a means of isolating circuits or bus sections, where operation is infrequent and a circuit breaker cannot be economically justified. The element 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 element is racked into position, it connects the upper set of the metal-clad switchgear primary disconnect devices to the lower set.

**WARNING**

Under no conditions may the dummy element be racked in or out when the circuit it is connected to is under load. This action could result in death or serious injury.

Key interlocks are applied to ensure that all source of power is disconnected before operating the dummy removable element. The key interlock used is similar to that described in Ch 5 Operation, and is set up for the “Lock in and out” mode of operation.

The interference plates provided on the dummy removable element 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 removable element into any circuit breaker compartment. It may be possible to insert a circuit breaker removable element into a dummy removable compartment as far as the disconnect position, but it cannot be racked into the compartment because there is no secondary disconnect devices to perform the necessary interlock functions.
N. **Ground and Test Device**

The PowlVac® ground and test device is a removable element which is mounted on a frame similar to the frame of a circuit breaker. 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, and conducting certain high voltage withstand tests (hipot). Insulation and isolation barriers between phases, and between phase and ground are also provided where required.

O. **Test and Inspection**

---

**WARNING**

Do not connect primary cable/bus or control wiring of the switchgear assembly to an energized system until all preliminary tests have been made to the switchgear assembly.

---

For test and inspection instructions, refer to applicable instruction bulletins and any supplemental documents. For assistance with testing and inspection, contact Powell on our website at powellind.com, or call 1.800.480.6900.

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**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.

---

After the equipment has been installed and all connections made, it should be tested and inspected before putting in service. Although the equipment and devices have been completely tested at the factory, a final field test should be made to ensure that the equipment has been properly installed and that all connections are correct and have not become loose in transportation.

If users perform AC hipot testing on high voltage cables used to connect the switchgear to loads, the following testing practices are recommended:

1. AC hipot testing voltage must be limited to no more than 60kV (75% of 80kV). DC hipot testing is not recommended. If DC hipot testing must be performed, consult with Powell prior to testing.
2. Surge arrestors, if present, must be disconnected before hipot testing.
3. Voltage Transformers and Control Power Transformers must be moved to the “DISCONNECTED” position before AC hipot testing.

Directions for testing devices such as relays, instruments and meters are given in the instruction book furnished for each device. The settings of the protective relays must be coordinated with the other relays on the system and, therefore, these relays must be set by the user. General instruction books are furnished with the equipment, containing the instruction material for all individual devices used in the equipment.
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 to the switchgear should be large enough to avoid excessive voltage drop. When supplied by a battery, the voltage at the terminals of the operating coils, shall not be less than the values listed in Table L, Rated Control Power Voltages and Ranges for Circuit Breakers.

Check continuity between all moving and stationary contacts of voltage transformer and fuse rollouts in both the connected and disconnected (or grounded) positions. The continuity may be verified with a multimeter or continuity tester by connecting one test lead to the bus phase that the stationary device is connected to and the second lead connected to the corresponding phase fuse holder cap. The fuses must be in place for continuity.

The covers for meters, relays, and other devices which have to be 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.

**CAUTION**

Wire connections, accessible bolted bus connections, and insulated joints should be examined to make sure they have not been loosened or damaged during shipment or installation.

After the switchgear has been installed and put into operation, the drawings supplied with the equipment should be reviewed and notations made on them of any changes made during the installation.

<table>
<thead>
<tr>
<th>Nominal Control Power Voltage</th>
<th>Voltage Range Required at Tripping Coil Terminals</th>
<th>Voltage Range Required (dc) at Closing Coil Terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>24VDC</td>
<td>14 to 28 VDC</td>
<td>---</td>
</tr>
<tr>
<td>48VDC</td>
<td>28 to 56 VDC</td>
<td>38 to 56 VDC</td>
</tr>
<tr>
<td>125VDC</td>
<td>70 to 140 VDC</td>
<td>100 to 140 VDC</td>
</tr>
<tr>
<td>250VDC</td>
<td>140 to 280 VDC</td>
<td>200 to 280 VDC</td>
</tr>
<tr>
<td>120VAC</td>
<td>104 to 127 VAC</td>
<td>104 to 127 VAC</td>
</tr>
<tr>
<td>240VAC</td>
<td>208 to 254 VAC</td>
<td>208 to 254 VAC</td>
</tr>
</tbody>
</table>

**WARNING**

Do not attempt to energize the equipment until all connections are verified. Improper connections could result in death or serious injury.
A. General

Contact Powell Service Division for assistance in performing maintenance or setting up a maintenance program. Email 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**

*When performing maintenance the power source must be disconnected and the equipment grounded. Failure to do so may result in death or serious injury.*

---

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**

*Do not place any object in this air space when energized. If done, it could result in equipment damage and/or minor or moderate injury to personnel.*

---

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.

3) **Mechanisms**

   Clean the mechanisms and lubricate wear points. The application of lubricants should be held to a minimum, which reduces the accumulation of dust and dirt.

4) **Primary Disconnect Device Contacts**

   Check the primary disconnect device contacts for signs of abnormal wear or overheating. Clean the contacts with a silver polish. Discoloration of the silvered surfaces is not ordinarily harmful, unless the atmospheric conditions cause deposits, such as sulfides on the contacts. If necessary, the deposits can be removed with a good grade of silver polish. Before placing or replacing the circuit breaker into service, apply a thin coat of contact lubricant to main contacts for lubrication.

5) **Disconnecting Contacts**

   Inspect all primary and secondary disconnecting devices (such as those on rollout transformers) for abnormal wear, fatigue, or overheating. Replace, if necessary, otherwise treat the same as primary disconnect device contacts.

---

**CAUTION**

*Inhalation of vapor could result in minor or moderate injury.*

**CAUTION**

*Use only the cleaners recommended in this document. Failure to do so could result in equipment damage.*

**CAUTION**

*Inhalation of vapor could result in minor or moderate injury.*
6) **Control Contacts**

The contacts should be inspected and dressed or replaced when the surface becomes seriously pitted. Unless repetitive duty has been experienced, little attention should be required.

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. See Table C, Bolt 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) Doors

Verify that all doors open without interference.

a. 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.

b. 3000A doors have a ventilation pattern of rectangular slots. Make sure all slots are open and air flow is possible, not blocked by foreign objects.
15) **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.

16) **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 it slides freely. Lubricate with a small amount of A - Grease if needed.

17) **4000A Versions Only**

a. Inspect the inside of the circuit breaker compartment near the forced cooled ventilation entry vents (Figure 38, e) and clean any loose debris and dust build-up.

b. Clean any dust build-up on the forced cooled ventilation exit (Figure 38, a) and fan package (Figure 38, b).

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

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 38 4000A Force Cooled Section Views

a. Force Cooled Ventilation Exit
b. Fan Package
c. Rear Cell Ventilation Duct
d. Circuit Breaker Compartment Door
e. Force Cooled Ventilation Entry
Recommended Renewal Parts and Replacement Procedures

Ch 7  Recommended Renewal Parts and Repair Procedure

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 Accessories, 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® switchgear. Refer to the Qualified Persons section in the front of this instruction bulletin.
### Table M Accessories

<table>
<thead>
<tr>
<th>Description</th>
<th>Breaker Type</th>
<th>Recommended Quantity</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Standard Racking</strong></td>
<td><strong>Closed-Door Racking</strong></td>
<td></td>
</tr>
<tr>
<td>Secondary Disconnect Override Device</td>
<td>51555G01</td>
<td>51555G03</td>
<td></td>
</tr>
<tr>
<td>Secondary Disconnect Override Device for Series 4 Circuit Breaker</td>
<td>n/a</td>
<td>51702G32</td>
<td></td>
</tr>
<tr>
<td>Manual Charging Handle</td>
<td>50235P01</td>
<td>50235P01</td>
<td></td>
</tr>
<tr>
<td>Racking Handle</td>
<td>50218G01</td>
<td>50218G01</td>
<td></td>
</tr>
<tr>
<td>Racking Start Extension</td>
<td>51066G01</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>CPT Secondary Disconnect</td>
<td>90421G01P</td>
<td>90421G01P</td>
<td></td>
</tr>
<tr>
<td>PT Secondary Disconnect</td>
<td>90422G01P</td>
<td>90422G01P</td>
<td></td>
</tr>
<tr>
<td>PowlVac Lubrication Kit</td>
<td>Powlube-104</td>
<td>Powlube-104</td>
<td></td>
</tr>
</tbody>
</table>
### Table N Lift Trucks

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Space Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>51571G05</strong></td>
<td>PowlVac and PowlVac-AR two-high switchgear. (ARG, ARM, ASD, CDA, CDR, GCB, &amp; STD circuit breakers &amp; electrically/manually operated G&amp;T) Lowers completely to the floor. Maximum tray height - 71 inches.</td>
<td>68 ½ inch turning aisle 42 inch entry door &amp; access aisle</td>
</tr>
<tr>
<td><strong>46039G05</strong></td>
<td>Identical to lift truck 51571G05 (above) with Ampgard contactor tray (46039G02) included. Note: Lift truck #51571G05 is included in this assembly. Do NOT order 51571G05 separately when ordering this option.</td>
<td>68 ½ inch turning aisle 42 inch entry door &amp; access aisle</td>
</tr>
<tr>
<td><strong>46040G03</strong></td>
<td>PowlVac and PowlVac-AR two-high switchgear. (ARG, ASD, CDA, CDR, GCB, &amp; STD circuit breakers) Lowers completely to the floor. Maximum tray height - 71 inches. This lift truck will not accommodate ARM Circuit Breakers or an electrically operated G&amp;T.</td>
<td>60 inch turning aisle 42 inch entry door &amp; access aisle</td>
</tr>
<tr>
<td><strong>46040G01</strong></td>
<td>Identical to lift truck 46040G03 (above) with Ampgard contactor tray (46039G02) included. PowlVac and PowlVac-AR two-high switchgear. (ARG, ASD, CDA, CDR, GCB, &amp; STD circuit breakers) Lowers completely to the floor. Maximum tray height - 71 inches. This lift truck will not accommodate ARM Circuit Breakers or an electrically operated G&amp;T.</td>
<td>60 inch turning aisle 42 inch entry door &amp; access aisle</td>
</tr>
<tr>
<td><strong>0144D2933G001</strong></td>
<td>This lift truck is for switchgear rollouts only. Will not reach a roof mounted PT/CPT tray Lowers completely to the floor. Maximum lift height - 76 ½ inches.</td>
<td>71 inch turning aisle 42 inch entry door &amp; access aisle</td>
</tr>
</tbody>
</table>
01.4IB.51000D
PowlVac® Metal-Clad Switchgear

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

February 2018