







# Instruction Bulletin - 01.4IB.77020 PowlVac-ND® and PowlVac-NDA™ Series 4 Vacuum Circuit Breakers

5kV / 1200A & 2000A / 36kA & 50kA



## **Contact Information**

## **Powell Electrical Systems, Inc.**

powellind.com info@powellind.com

## **Service Division**

7232 Airport Blvd. Houston, Texas 77061

713.944.6900 phone 713.948.4569 fax









## **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:

# **A DANGER**

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

## **A WARNING**

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

## **A CAUTION**

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

## **CAUTION**

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

# NOTICE

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

#### **Qualified Person**

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

- 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.



This page is intentionally left blank.









## **Contents**

Ch 1	General Information	
A.	Scope	2
B.	Purpose	2
C.	Instruction Bulletins Available Electronically	2
	Associated Bulletins	
Ch 2	Safety	3
	Safe Work Condition	
	Safety Guidelines	
	GENERAL	
	Specific	
	X-Rays	
	SAFETY LABELS	
	Equipment Description	
	GENERAL DESCRIPTION	
В.	THE STORED ENERGY MECHANISM	
	1) Mechanical Description	
	2) Electrical Description	
C.	RACKING MECHANISM FOR POWLVAC-ND® SERIES 4 CIRCUIT BREAKER	
	1) General Description	
	2) Closed Door Racking Mechanism	
D.	AUTOMATIC RACKING MECHANISM FOR POWLVAC-NDA™ SERIES 4 CIRCUIT BREAKER	
	1) General Description	
	2) Racking Mechanism	
E.	CIRCUIT BREAKER COMPARTMENT INTERFACES	
	1) Primary Disconnecting Devices	
	2) Secondary Disconnecting Devices	
	3) MOC (Mechanism Operated Cell Switch) Actuator	
	4) TOC (Truck Operated Cell Switch) Actuator	
	5) Ground Connection	
	6) Shutter Rollers	
-	Vacuum Interrupters	
	Vacuum Interrupters	
G.	V ACUUM INTERKUPTER CONNECTIONS	



## **Contents**

Ch 4	Installation	24
A.	Receiving	24
B.	Handling	24
C.	Storage	25
D.	PLACING THE CIRCUIT BREAKER INTO SERVICE	26
	1) High Voltage Insulation Integrity	26
	2) Vacuum Integrity	
	3) Control Voltage Insulation Integrity	28
	4) Mechanical Operation Check	29
	5) Electrical Operation Check	
	6) Emergency Racking Mechanism Check (PowlVac-NDA™ Series 4 Circuit Breaker Only)	30
E.	RACKING PROCEDURES FOR POWLVAC-ND® SERIES 4 CIRCUIT BREAKER	31
	1) Prior to Inserting the Circuit Breaker into the Circuit Breaker Compartment	32
	2) Inserting the Circuit Breaker to the Test/Disconnected Position	
	3) Inserting the Circuit Breaker to the Connected Position	
	4) Removing the Circuit Breaker from the Connected to the Test/Disconnected Position	35
	5) Removing the Circuit Breaker from the Test/Disconnected Position out of the	
	Circuit Breaker Compartment	
	6) Remote Racking	
F.	RACKING PROCEDURES FOR POWLVAC-NDA™ SERIES 4 CIRCUIT BREAKER	37
	1) Prior to Inserting the Circuit Breaker into the Circuit Breaker Compartment	
	2) Inserting the Circuit Breaker to the Test/Disconnected Position	
	3) Inserting the Circuit Breaker to the Connected Position	
	4) Emergency Racking In Procedure	
	4) Removing the Circuit Breaker from the Connected to the Test/Disconnected Position	40
	5) Removing the Circuit Breaker from the Test/Disconnected Position out of the	
	Circuit Breaker Compartment	
	6) Emergency Racking Out Procedure	41
Ch 5	Maintenance	43
Α.	General Description	43
	1) Introduction	
	2) Inspection and Cleaning	
В.		
	1) Mechanical Operation	
	2) Lubrication	
	3) Closing Spring Removal	
	4) Slow Closing of Mechanism	
	5) Mechanism Adjustments	
	6) Electrical Operation	









## **Contents**

C.	. VACUUM INTERRUPTER AND CONTACT AREA	55
	1) Vacuum Interrupter and Contact Erosion	55
	2) Sliding Contact Finger Wear	56
	3) Vacuum Integrity	
	4) Mechanical Adjustment of Vacuum Interrupters	
D.	OPTIONAL MAINTENANCE PROCEDURES	
	1) High Potential Tests	
	2) Timing	
	3) Primary Resistance Check	
Ch 6	Recommended Renewal Parts and Replacement Procedu	ures58
A.	. Ordering Instructions	58
	. RECOMMENDED RENEWAL PARTS	
C.	. Replacement Procedures	58
	1) Vacuum Interrupter Assembly	
	2) Closing Coil Assembly	
	3) Primary Shunt Trip Coil Assembly	59
	4) Secondary Shunt Trip Coil Assembly	
	5) Undervoltage Device Assembly	
	6) Charging Motor Assembly	
	7) Anti-Pump Relay Assembly	
	8) Latch Check Switch	
	9) Motor Cutoff Switch Assembly	
	10) Auxiliary Switch	50



# **Figures**

Figure 1	iypicai Powivac-ND° Series 4 vacuum Circuit Breaker	8		
Figure 2	Typical PowlVac-NDA™ Series 4 Vacuum Circuit Breaker	8		
Figure 3	PowlVac-NDA™ Circuit Breaker - Exterior View			
Figure 4	PowlVac-NDA™ Circuit Breaker - Interior View			
Figure 5	Cam and Fundamental Linkage Positions	11		
Figure 6	Mechanism and Trip Linkages	12		
Figure 7	Operation Sequence	14		
igure 8 Typical Control Scheme		15		
Figure 9 Closed Door Racking Mechanism and Interlock		19		
Figure 10	Circuit Breaker in Shipping Carton	24		
Figure 11 Circuit Breaker on Crane		25		
Figure 12	Secondary Disconnect Device	34		
Figure 13	Racking Handle Insertion	34		
Figure 14	Circuit Breaker Anti-Rollout Latch	36		
Figure 15	Lubrication	47		
Figure 16	Lubrication (cont)	48		
Figure 17	Main Closing Spring Assembly Installed	49		
Figure 18	Main Closing Spring Assembly Compressed for Removal	49		
Figure 19	Primary & Secondary Trip Prop Adjustment			
Figure 20	Feeler Gauge			
Figure 21	Latch Check Switch Adjustment	53		
Figure 22	Measurement of Open Position	55		
Figure 23	Measurement of Closed Position	55		
Figure 24	Primary Current Path	60		
Figure 25	Control Devices	62		
	Tables			
Table A Fi	eld Dielectric Test Values	26		
Table B Lu	brication	46		
Table C Timing				
	imary Resistance			
Table E Pr	imary Current Path	60		
	ntrol Devices			
Table G M	iscellaneous Parts	63		









This page is intentionally left blank.









### Ch 1 General Information

## **A 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

This instruction bulletin is intended to assist users in the design and safe operation of these PowlVac-ND® and PowlVac-NDA™ circuit breakers:

- 05PV36SNDX-4, 1200 & 2000A
- 05PV50SNDX-4, 1200 & 2000A
- 05PV36SNDM-4, 1200 & 2000A
- 05PV50SNDM-4, 1200 & 2000A
- 05PV36NDAX-01 (24-pin; out of production)
- 05PV36NDAX-4, 1200 & 2000A
- 05PV50NDAX-4, 1200 & 2000A
- 05PV36NDAM-4, 1200 & 2000A
- 05PV50NDAM-4, 1200 & 2000A

#### B. PURPOSE

The information in this instruction bulletin is intended to provide the details required to properly operate and maintain the circuit breakers described in *Ch 1 General Information, A. Scope*.

This instruction bulletin provides:

- 1. Guidelines for safety.
- 2. General descriptions of the operation and maintenance of the circuit breakers.
- 3. Instructions for installation and placing the circuit breakers into service.
- 4. Instructions for part replacement.
- 5. Renewal parts lists.

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

All illustrations and photos are shown using deenergized equipment.

## **A 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 because they 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.

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 Instruction Bulletin number in the subject line.

#### D. ASSOCIATED BULLETINS

- 01.4IB.78000A PowlVac-ND® Metal-Clad Switchgear
- 01.4IB.78200 PowlVac-NDAR® Arc Resistant Switchgear
- 01.4IB.51808A Vacuum Type Remote Racking Device (51897G29)
- 01.4IB.49001 PowlVac® Series 4 Test Cabinet









## Ch 2 Safety

#### A. SAFE WORK CONDITION

The information in Section A is quoted from NFPA 70E 2018 - Article 120, 120.5 Establishing an Electrically Safe Work Condition.

120.5 Process or Establishing and Verifying an Electrically Safe Work Condition. Establishing and verifying an electrically safe condition shall include all of the following steps, which shall be performed in the order presented, if feasible:

- 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.
- 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. Release stored electrical energy.
- 5. Release or block stored mechanical energy.
- Apply lockout/tagout devices in accordance with a documented and established procedure.
- 7. Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

- Exception No. 1: An adequately rated permanently mounted test device shall be permitted to be used to verify the absence of voltage of the conductors or circuit parts at the work location, provided it meets the all following requirements: (1) It is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the point of work; (2) It is listed and labeled for the purpose of verifying the absence of voltage; (3) It tests each phase conductor or circuit part both phase-to-phase and phase-toground; (4) The test device is verified as operating satisfactorily on any known voltage source before and after verifying the absence of voltage.
- **N** Exception No. 2: On electrical systems over 1000 volts, noncontact test instruments shall be permitted to be used to test each phase conductor.
  - Informational Note No. 1: See UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements, for rating, overvoltage category, and design requirements for voltage measurement and test instruments intended for use on electrical system 1000 volts and below.
- N Informational Note No. 2: For additional information on rating and design requirements for voltage detectors, refer to IEC 61243-1, Live Working Voltage Detectors Part 1: Capacitive type to be used for voltages exceeding 1kV a.c., or IEC 61243-2, Live Working Voltage Detectors Part 2: Resistive type to be used for voltages of 1kV to 36kV a.c., or IEC 61243-3, Live Working Voltage Detectors Part 3: Two-pole voltage type.



- 8. 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 de-energized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:
  - a.. Placement. Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard (i.e., hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the employer's job planning.
  - Capacity. Temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.
- N Informational Note: ATSM F855, Standard Specification for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment, is an example of a standard that contains information on capacity of temporary protective grounding equipment.
  - c. Impedance. Temporary protective grounding equipment and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

### B. SAFETY GUIDELINES

Study this instruction bulletin and all other associated documentation before uncrating the equipment.

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 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  $PowlVac-ND^{\circ}$  and  $PowlVac-NDA^{\mathsf{TM}}$  Series 4 circuit breakers.









### C. GENERAL

- Only qualified personnel trained in the usage, installation, operation, and maintenance of the circuit breaker 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 the circuit breaker's reliability and safety.
- 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

- DO NOT WORK ON AN ENERGIZED CIRCUIT BREAKER. If work must be performed on a circuit breaker, remove it from service and remove it from the metal-clad switchgear.
- 2. DO NOT WORK ON A CIRCUIT BREAKER 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 mechanisms 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 this instruction bulletin.
- 4. DO NOT ATTEMPT TO CLOSE THE CIRCUIT BREAKER MANUALLY ON AN ENERGIZED CIRCUIT.
- 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 CIRCUIT BREAKERS.
- Interlocks are provided to ensure the proper operating sequences of the circuit breakers and for the safety of the user. If for any reason an interlock does not function as described, do not make any adjustments, modification, or deform the parts. DO NOT FORCE THE PARTS INTO POSITION. CONTACT POWELL FOR INSTRUCTIONS.



### E. X-Rays

When high voltage is applied across the contacts of a vacuum interrupter, there is the possibility of generation of X-rays. The intensity of the X-radiation is dependent on the peak voltage and the contact gap. At the normal operating voltage for this type of equipment, the radiation levels are negligible. At the voltages specified for testing, test personnel shall be in front of the circuit breaker such that the two layers of steel used in the frame and front cover construction are between the test personnel and the vacuum interrupters, and that the test personnel be no closer than one meter (3') from the front of the circuit breaker. THE CIRCUIT BREAKER SHALL BE EITHER **FULLY OPEN, OR FULLY CLOSED WHEN** MAKING HIGH POTENTIAL TESTS. DO NOT **TEST WITH CONTACTS PARTIALLY OPEN.** 

#### F. SAFETY LABELS

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



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 DESCRIPTION



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, contact Powell before attempting to perform any actions.

PowlVac-ND® Series 4 (Figure 1) and PowlVac-NDA™ Series 4 (Figure 2) Vacuum Circuit Breakers use sealed vacuum interrupters (Figure 3, v) to control the primary circuit. The primary connections to the associated metal-clad switchgear are made by parallel copper busbars terminating in multiple contact fingers of the primary disconnecting devices (Figure 3, u & w). The primary disconnecting devices, busbars, and vacuum interrupter assemblies are supported by insulating supports (Figure 3, r & s) specifically designed for the application.

The primary current path side of the circuit breaker is considered the rear of the circuit breaker, while the side with the cover containing the various indicators and manual operators is considered the front of the circuit breaker. By removing the front cover, the operating mechanisms of the circuit breaker are exposed. The stored energy mechanism assembly provides motion to each of the vacuum interrupter moving contact assemblies through operating pushrods (Figure 3, al). In the same metal enclosed compartment as the stored energy mechanism is the circuit breaker

racking mechanism and interlocks which control the movement of the circuit breaker between the test/disconnected and connected positions. The racking mechanism provides the motion to engage/disengage the primary disconnecting devices and to open/close the shutters in metal-clad switchgear.

#### B. THE STORED ENERGY MECHANISM

### 1) Mechanical Description

The stored energy mechanism is located in the front of the circuit breaker behind the front cover. The front cover is held in place by ten (10) cover bolts (Figure 3, a) that may be removed, allowing access to the stored energy mechanism and its interlocks, auxiliary switches, racking mechanism, and other control devices.

## **A CAUTION**

Prior to removing the front cover, ensure the circuit breaker is in the OPEN position and the main closing spring is fully discharged. Failure to do so may result in injury.

On the escutcheon of the stored energy mechanism, there are two (2) indicators that show the various states of operation of the mechanism and two (2) manual operators that will open/close the stored energy mechanism. The circuit breaker nameplate (Figure 3, g) is also located on the mechanism escutcheon. If for any reason the escutcheon is removed from the circuit breaker, it shall be verified that the serial number contained on the nameplate matches the engraved serial number plate (Figure 3, z) permanently affixed to the rear of the circuit breaker frame prior to installing the escutcheon.



The mechanism employed in the circuit breaker is a stored energy system which uses a charging motor to compress the main closing spring. During the closing operation the energy stored in the main closing spring is released. This allows the mechanism to close the vacuum interrupter contacts, compress the contact loading springs, charge the opening springs, and overcome frictional forces. When the circuit breaker is opened, the energy stored in the opening and contact loading springs is released, and the vacuum interrupter contacts are opened.

The charging motor (Figure 4, m), located on the bottom right of the mechanism compartment, is assembled to the circuit breaker by a cover plate which is bolted to the circuit breaker right frame side sheet. The charging motor drive shaft inserts into the eccentric drive shaft. The eccentric drive shaft is supported by needle roller bearings in the mechanism frame side sheets and transmits the motor torque to the left side of the mechanism.

When the charging motor is energized, the eccentric drive shaft rotates and causes the pawl support arms to pivot about the camshaft (Figure 4, k). The drive pawl, which is supported by the arms, engages with the ratchet wheel and drives the ratchet wheel one tooth at a time. To prevent backwards motion of the ratchet wheel, a springloaded holding pawl is used to latch the ratchet wheel after each advance from the drive pawl.

To ensure correct synchronization of the drive and holding pawl, the position of the holding pawl support arms are adjustable by the holding pawl adjusting eccentric (Figure 4, t) located at the left front of the mechanism. When the mechanism is operated manually, the top pawl becomes the drive pawl and the bottom pawl becomes the holding pawl.

The ratchet wheel (Figure 4, v) has projections from its side faces which engage the drive plates as it rotates. These drive plates are attached to the camshaft, thus causing the camshaft to rotate. Attached to the ends of the camshaft are crank arms (Figure 4, u). Crank pins (Figure 4, s) are assembled to the crank arms, which point outward. The crank arms engage the bottom ends of the connecting rods (Figure 4, e). The pins that project from the spring yoke, which straddles the main closing spring, engage the top ends of the connecting rods. As the camshaft rotates the connecting rods will pull the spring yoke downward, compressing the main closing spring.

The ratchet wheel will drive the camshaft so that the connecting rods go down to their lowest position, and then start to move upward. At a certain point, the spring force will overcome friction and resistance and start to rotate the camshaft. At the same time, the pawls are uncoupled from the ratchet wheel by the pawl lift plate (Figure 4, w) and the motor cutoff switch is operated.

The motor cutoff switch (Figure 4, af), located at the right of the mechanism, is operated by the spring charge indicator and motor cutoff cam (Figure 4, ac). The spring charge indicator (Figure 3, o) will display that the mechanism is charged.





Figure 1 Typical PowlVac-ND® Series 4 Vacuum Circuit Breaker

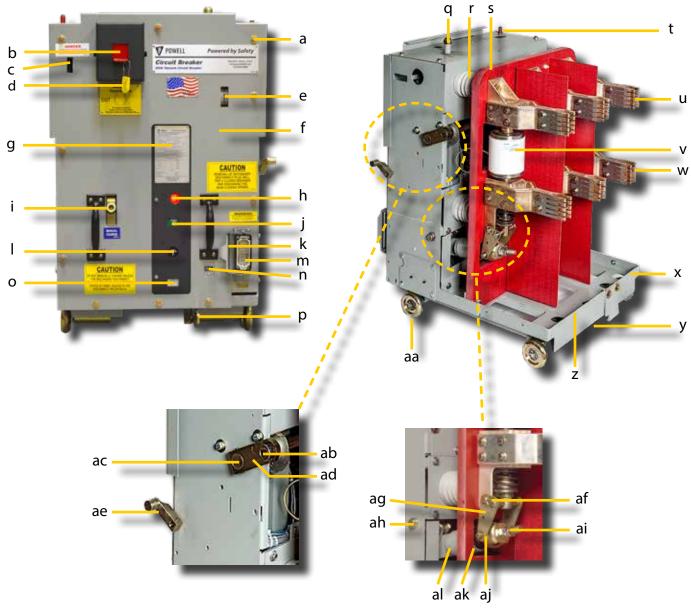


Figure 2 Typical PowlVac-NDA™ Series 4 Vacuum Circuit Breaker





Figure 3 PowlVac-NDA™ Circuit Breaker - Exterior View



- a. Cover Bolts
- b. Emergency Racking Drive Shaft Shutter
- c. Circuit Breaker Monitor IR Window
- d. Padlock Seal
- e. Breaker Position Indicator
- f. Front Cover
- g. Nameplate
- h. Manual Trip Operator
- i. Manual Charging Crank
- j. Circuit Breaker Open/Closed Indicator
- k. Secondary Disconnect Latch
- I. Manual Close Operator
- m. Secondary Disconnect Receptacle

- n. Operations Counter
- o. Spring Charge Indicator
- p. Anti-Rollout Latch
- g. MOC Actuator
- r. Standoff Insulator
- s. Vacuum Interrupter Support
- t. TOC Actuator
- u. Upper Primary Disconnecting Device
- v. Vacuum Interrupter
- w. Lower Primary Disconnecting Device
- x. Frame
- y. Ground Connection
- z. Serial Number Plate Location

- aa. Wheel
- ab. Crank Arm Roller
- ac. Racking Shaft
- ad. Racking Crank Arm
- ae. Manual Trip Lever
- af. Operating Pin
- ag. Bell Crank
- ah. Jackshaft Pin
- ai. Lock Nut
- aj. Spring Yoke
- ak. Contact Loading Spring
- al. Operating Pushrod

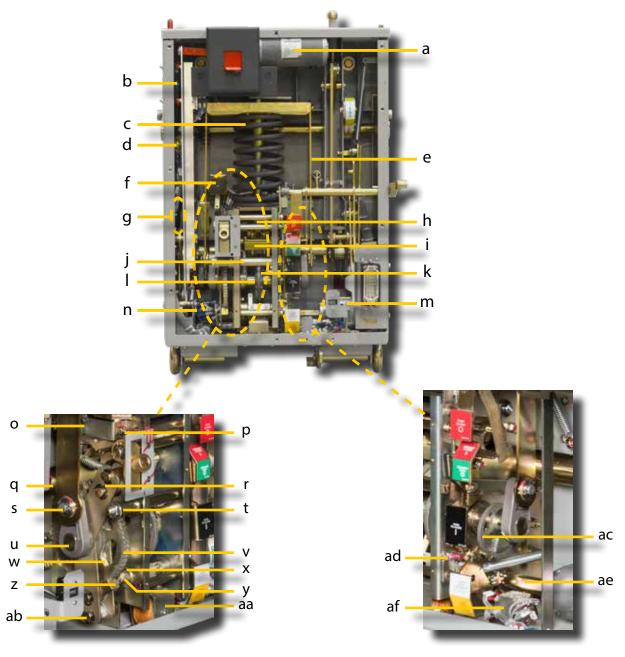








Figure 4 PowlVac-NDA™ Circuit Breaker - Interior View

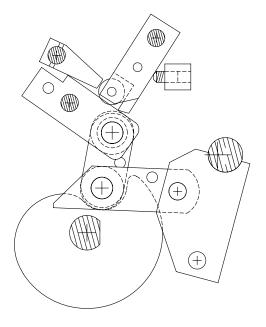


- a. Racking Motor
- b. Circuit Breaker Monitor™ (Optional)
- c. Main Closing Spring
- d. Anti-Pump Relay
- e. Connecting Rod
- f. Primary Shunt Trip Coil
- g. Shock Absorber (Dashpot)
- h. Secondary Trip Prop
- i. Main Cam Roller
- j. Reset Spring

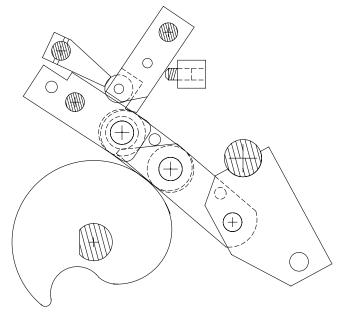
- k. Camshaft
- I. Main Closing Cam
- m. Charging Motor
- n. Auxiliary Switch
- o. Latch Check Switch
- p. Secondary Trip Prop Adjusting Screw
- q. Jackshaft
- r. Holding Pawl Support Arm
- s. Crank Pin
- t. Holding Pawl Adjusting Eccentric
- u. Crank Arm

- v. Ratchet Wheel
- w. Pawl Lift Drive Plate
- x. Close Latch Arm
- y. Close Latch Shaft
- z. Drive Pawl
- aa. Closing Coil
- ab. Pawl Support Arm
- ac. Motor Cutoff Cam
- ad. Close Bar Adjusting Screw
- ae. Charging Motor Drive Shaft
- af. Motor Cutoff Switch

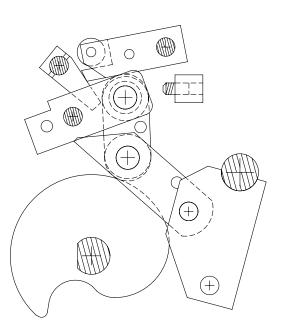
## Figure 5 Cam and Fundamental Linkage Positions



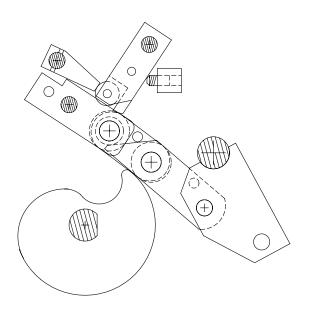
a) Breaker Open - Spring Charged - Links Reset



b) Breaker Closed - Spring Discharged



c) Breaker Open - Spring Discharged



d) Breaker Closed - Spring Charged

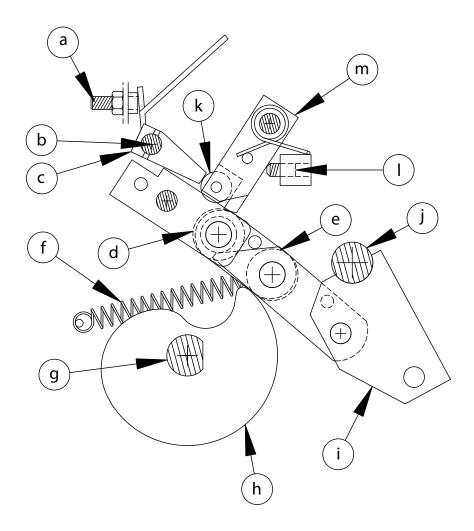








Figure 6 Mechanism and Trip Linkages



- a. Secondary Trip Prop Adjusting Screw
- b. Secondary Trip Prop Shaft
- c. Secondary Trip Prop
- d. Secondary Linkage Roller
- e. Main Cam Roller
- f. Reset Spring
- g. Camshaft
- h. Main Closing Cam
- i. Center Phase Operating Lever
- j. Jackshaft
- k. Primary Trip Prop Roller
- I. Primary Trip Prop Adjusting Screw
- m. Primary Trip Prop



The camshaft would continue to rotate, except that it is restrained by the close latch arm (Figure 4, x) engaging against the close latch shaft (Figure 4, y). The main closing cam, located between the mechanism side sheets, is now in a position where the fundamental linkage can move to the reset position.

The close latch, when released either by the closing coil or the manual close operator, allows the main closing spring to pull the crank arms upward thus rotating the main closing cam and driving the fundamental linkage into the closed position. This causes the main linkage to rotate the jackshaft such that the operating pushrods are driven toward the current carrying side of the circuit breaker.

Each operating pushrod assembly has a recess at each end which encloses a contact loading spring (Figure 3, ak). At the end of this spring is a spring yoke (Figure 3, aj), which connects with bell cranks. The spring yoke is restrained by a lock nut on a stud which passes through the contact loading spring and is attached to the operating pushrod assembly. The contact loading spring has initial compression such that as soon as the vacuum interrupter contacts touch, the springs are preloaded to a value sufficient to resist vacuum interrupter contact separation under the highest electromagnetic forces exerted by the rated short-circuit current. Further movement of the operating pushrod assembly compresses the contact loading spring even more and produces a gap between the face of the spring yoke and the lock nut.

For each phase, bell cranks (Figure 3, aq) are located on the outside of the lower primary disconnecting devices (Figure 3, w) and are supported by bearings. Each bell crank is connected to an operating pin, which passes through a slot in the lower primary disconnecting devices and engage an extension to the vacuum interrupter assembly thus moving the vacuum interrupter contact. The bell cranks give an approximate 3 to 1 multiplication of the contact loading spring force, enabling a lower spring rate to be used. It also multiplies the contact movement by a factor of approximately 3, so that the mechanism linkages have relatively large movements and are less critical.

In the cam and fundamental linkage positions (Figure 5, b & d), the contact loading springs and the main opening springs are both acting to compress the three (3) main mechanism links. The jackshaft extends from the left to the right side of the circuit breaker frame and is supported at the main circuit breaker frame side sheets and by the mechanism side sheets. The outer operating levers on the jackshaft have connections to the circuit breaker auxiliary switch and MOC operating linkage.









Figure 7 Operation Sequence

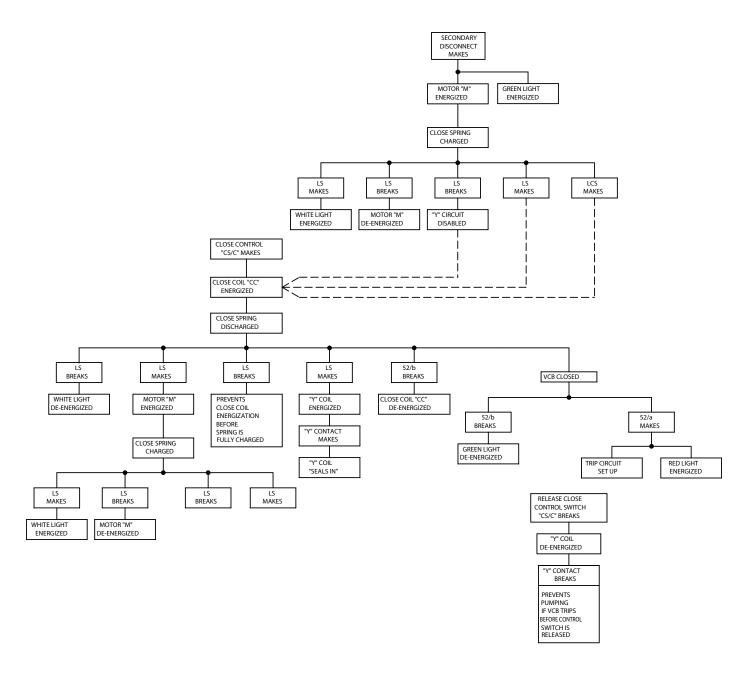
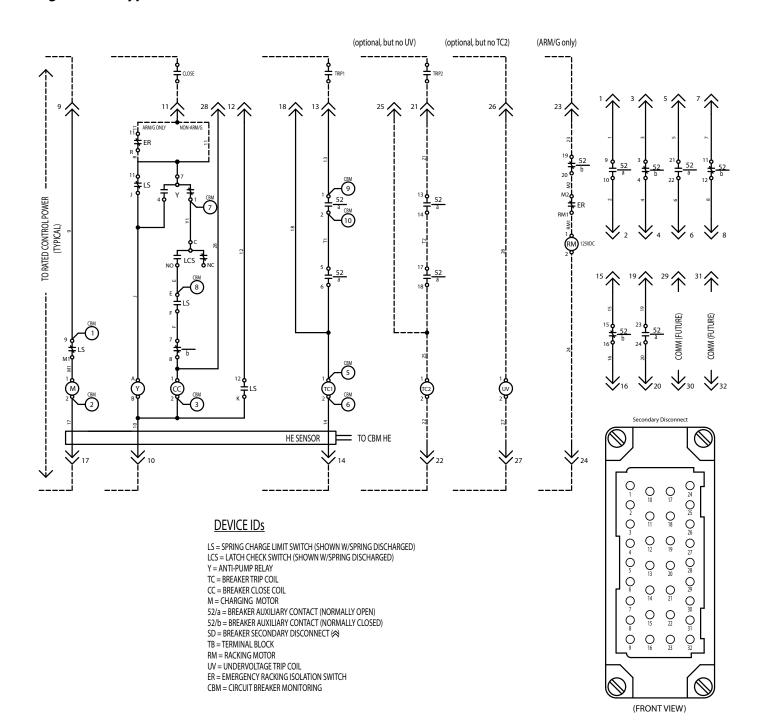




Figure 8 Typical Control Scheme











The fundamental linkage is restrained from movement by the secondary trip prop acting on the primary trip prop roller. A component of force tends to make the primary trip prop rotate upward, but it is restrained by the secondary trip prop face acting on the primary trip prop roller. The clearance between the primary trip prop roller and the secondary trip prop is controlled by the primary trip prop adjusting screw. When the trip shaft is rotated by the action of the manual trip operator or the primary shunt trip coil, the secondary trip prop face moves downward and permits the primary trip prop to rotate upward, thus permitting the main linkage to move upward and the jackshaft to rotate, opening the circuit breaker. The left jackshaft levers engage a shock absorber (Figure 4, q), which controls the rebound of the vacuum interrupter contacts on an opening operation.

With the standard electrical control scheme, as soon as the main closing spring is discharged on a closing operation, the charging motor is switched on to recharge the springs. This leaves the main closing cam in a position where a tripped linkage can reset under the action of the reset spring (Figure 4, j) and the primary and secondary trip props can fall into the reset position. The reset spring stretches between an extension of the main cam roller pin and a spring support pin located on the left mechanism side sheet. The latch check switch (Figure 4, 0), operated by a lever on the trip shaft, will close as the secondary trip prop reaches the fully reset position.

### 2) Electrical Description

## a. Charging Motor

The function of the charging motor (Figure 4, m) is to compress the main closing spring of the stored energy mechanism, thus providing the necessary energy to close the circuit breaker. The charging motor, located at the bottom right of the base pan, is assembled to the circuit breaker by a cover plate that is bolted to the circuit breaker frame right side sheet.

#### b. Motor Cutoff Switch

The motor cutoff switch (Figure 4, af) provides an electrical break in the control circuit supplying the charging motor when the main closing spring is fully charged and the stored energy mechanism is ready for a closing operation. It is located at the bottom right of the mechanism, and is supported by a bracket which is bolted to the circuit breaker base pan.

## c. Anti-Pump Relay

The anti-pump relay (Figure 4, d) provides a logic function for the control circuit which prevents a continuous electrical close signal from causing the circuit breaker to continuously re-close after a trip signal. The anti-pump relay is located on the circuit breaker frame, inside the circuit breaker left frame side sheet, and is supported by two screws.



### d. Operating Solenoids

Electrical operation of the circuit breaker is accomplished using operating solenoids.

The closing coil (Figure 4, aa) is an operating solenoid that is located at the bottom center of the mechanism, and is assembled to the circuit breaker base pan by bolts accessible from underneath the circuit breaker.

The primary shunt trip coil (Figure 4, f) is located at the top left side of the mechanism, and is assembled to the lower frame channel by two bolts.

Either a secondary shunt trip coil or an undervoltage device may be furnished as an option. When furnished, either of these devices will be located at the top right side of the mechanism, installed on the lower frame channel. Only one of these two operating solenoids may be furnished on any one circuit breaker, as both devices are located in the same space.

#### e. Control Circuit

Typical AC and DC electrical control schemes are shown in *Figure 8*. The control scheme of any particular circuit breaker may differ from these typical schemes depending on the user's requirements, operating solenoids, and the control devices furnished with that circuit breaker.

The operation sequence for all control schemes is shown in *Figure 7*. Circuit breaker mounted auxiliary contacts not used in the control circuit are brought out for control and indication functions.

The metal-clad switchgear equipment may provide a circuit breaker MOC (Mechanism Operated Cell Switch) for additional contacts.

# C. RACKING MECHANISM FOR POWLVAC-ND® SERIES 4 CIRCUIT BREAKER

### 1) General Description

The racking mechanism is the mechanical assembly that facilitates moving the circuit breaker between the breaker test/disconnected and the connected positions in the circuit breaker compartment. The main racking mechanism components for the PowlVac-ND® Series 4 circuit breaker are shown and described in the following sections:

#### a. Breaker Position Indicator

The breaker position indicator (Figure 3, e) is visible through an opening in the circuit breaker front cover. The indicator displays whether the circuit breaker is in the connected or the test/disconnected positions. When the breaker position indicator displays "CONN", and this is fully visible in the aperture, the circuit breaker is in the connected position. When the breaker position indicator displays "TEST", and this is fully visible in the aperture, the circuit breaker is in the test/disconnected position. In positions other than the connected and test/disconnected positions, the breaker position indicator does not display an indication. Refer to Ch 4 Installation, E. Racking Procedures for the PowlVac-ND® Series 4 Circuit Breaker for more information.









### b. Interlocking

PowlVac® circuit breakers are provided with several interlocks that operate in conjunction with the circuit breaker compartment to ensure the proper operation of the circuit breaker. Do not attempt to modify or bypass these interlocks, as they are necessary for the safe operation of the circuit breaker. The following describes the interlocking for the closed door racking circuit breaker.

The purpose of the interlocks are to ensure:

- The circuit breaker cannot be moved from the test/disconnected to the connected position unless the main circuit breaker contacts are opened and the secondary control circuitry from the compartment to the circuit breaker is completed, and the circuit breaker cannot be removed from the connected to the test/disconnected position unless the main contacts are opened.
- The control circuits cannot be broken when the circuit breaker is in the connected position.
- The circuit breaker cannot be removed from the circuit breaker compartment with the circuit breaker closed or with the main closing spring charged.

Closed Door Racking (CDR) circuit breaker interlocking is primarily achieved by means of an interlock bar acting upon the racking drive shaft extension, an interlock bar attached to the secondary disconnect receptacle, and a tripping linkage and roller on the right side of the frame of the circuit breaker that interfaces with the circuit breaker compartment.

An interlock bar prevents the rotation of the racking drive shaft extension whenever the circuit breaker is closed or the secondary disconnect plug is removed. This prevents movement of the circuit breaker when the circuit breaker is closed, or when the control circuits are disconnected.

Racking the circuit breaker in from the test/disconnected position to the connected position also rotates a cam attached to the racking shaft. A cam follower, attached to a lever pivoted on the circuit breaker frame, drives a secondary disconnect locking bar downward. The locking bar engages a slot in the interlock bar attached to the secondary disconnect plug. The cam profile is arranged so that the lever can only be in its upward position when the racking crank arms are fully in the test/disconnected position.



This ensures that the control circuits cannot be disconnected in any position except the test/disconnected position. The tripping linkage and roller on the side of the circuit breaker frame follows a cam mounted in the circuit breaker compartment. The cam, in all intermediate positions between the test/disconnected and connected position, depresses the tripping roller. Depressing the tripping roller actuates the manual trip operator which holds the breaker in a trip free condition. The manual trip operator also actuates the latch check switch, thus blocking any electrical closing signal.

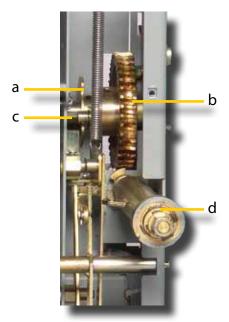
The interlock bar attached to the secondary disconnect also actuates the secondary trip prop shaft and the close latch upon removal from the circuit breaker. This final interlock ensures that the circuit breaker is in the open position and the main spring is discharged prior to removal from the compartment.

### 2) Closed Door Racking Mechanism

The closed door racking mechanism consists of a racking shaft (Figure 9, c) with racking crank arms (Figure 3, ad) at each end, which are supported by the frame side sheets. The racking shaft also supports a worm gear assembly (Figure 9, b) at the right end just inside the right side sheet. In addition, the racking crank arms have rollers attached to each end of the racking shaft, which engage the vertical slots of the racking cams in the circuit breaker compartment. Rotation of the racking crank arms will drive the circuit breaker into or out of the connected position. This action also operates the compartment shutters.

The two bolts on the left side sheet and the one bolt on the right side sheet serve as a positive stop to the crank arm. This positive stop prevents further rotation of the racking shaft, thus stopping circuit breaker travel. At this time, the breaker position indicator on the front of the circuit breaker will display "CONN".

Figure 9 Closed Door Racking Mechanism and Interlock



- a. Interlock Cam
- b. Worm Gear
- c. Racking Shaft
- d. Racking Drive Shaft Extension









# D. AUTOMATIC RACKING MECHANISM FOR POWLVAC-NDA™ SERIES 4 CIRCUIT BREAKER

### 1) General Description

The racking mechanism is the mechanical assembly that facilitates moving the circuit breaker between the breaker test/disconnected and the connected positions in the circuit breaker compartment. The main racking mechanism components for the PowlVac-NDA™ Series 4 circuit breakers are shown and described in the following sections:

#### a. Breaker Position Indicator

The breaker position indicator (Figure 3, e) is visible through an opening in the circuit breaker front cover. The indicator displays whether the circuit breaker is in the connected or the test/disconnected positions. When the breaker position indicator displays "CONN", and this is fully visible in the aperture, the circuit breaker is in the connected position. When the breaker position indicator displays "TEST", and this is fully visible in the aperture, the circuit breaker is in the test/disconnected position. In positions other than the connected and test/disconnected positions, the breaker position indicator does not display an indication. Refer to Ch 4 Installation, F. Racking Procedures for the PowlVac-NDA™ Series 4 Circuit Breaker for more information.

### b. Interlocking

PowlVac® circuit breakers are provided with several interlocks that operate in conjunction with the circuit breaker compartment to ensure the proper operation of the circuit breaker. Do not attempt to modify or bypass these interlocks, as they are necessary for the safe operation of the circuit breaker.

The purpose of the interlocks is to ensure:

- The circuit breaker cannot be moved from the test/disconnected to the connected position unless the main circuit breaker contacts are opened and the secondary control circuitry from the compartment to the circuit breaker is completed, and the circuit breaker cannot be removed from the connected to the test/disconnected position unless the main contacts are opened.
- The control circuits cannot be broken when the circuit breaker is in the connected position.
- The circuit breaker cannot be removed from the circuit breaker compartment with the circuit breaker closed or with the main closing spring charged.

The PowlVac-NDA™ circuit breaker interlocking is primarily achieved by means of an interlock bar attached to the secondary disconnect plug and tripping linkage and roller. Upon initial insertion of the circuit breaker into the compartment, a position interlock prevents moving the circuit breaker from the disconnected position to the test position without the secondary disconnect inserted.



The tripping linkage and roller beside the breaker frame follow a cam mounted in the circuit breaker compartment. The cam, in all intermediate positions between the test/disconnected and connected position, depresses the tripping roller. Depressing the tripping roller actuates the manual trip operator which holds the breaker in a trip free condition. The manual trip operator also actuates the latch check switch, thus blocking any electrical closing signal.

### c. Blocking Interlock

Access to the emergency racking drive is controlled by a blocking interlock. The emergency racking access shutter can only be opened with the circuit breaker open. Moving the emergency racking drive shaft shutter downward prevents the closing of the circuit breaker by operating a linkage which blocks the mechanism. If the breaker is not in the open position, the shutter cannot be opened enough to insert the racking handle. This interlock ensures that the circuit breaker is open when it is manually racked into the compartment. Once the circuit breaker reaches the operating position and the shutter mechanism is released, the circuit breaker can now be closed. When the circuit breaker is in the closed position, the shutter is no longer free to move. This blocks the operation of the emergency racking drive shaft, deterring any attempt to remove a closed circuit breaker from the compartment.

### 2) Racking Mechanism

The racking mechanism consists of a racking shaft (Figure 3, ac) with racking crank arms (Figure 3, ad) at each end which are supported by the frame side sheets. The racking motor (Figure 4, a) is located at the top of the racking shaft, inside the circuit breaker frame. In addition, the racking crank arms have rollers attached to each end of the racking shaft which engage the vertical slots of the racking cams in the circuit breaker compartment. Rotation of the racking crank arms will drive the circuit breaker into or out of the connected position. This action also operates the compartment shutters.

Bolts on the left and right side sheets provide a positive stop to the left crank arm. This positive stop prevents further rotation of the racking shaft, thus stopping circuit breaker travel. At this time, the breaker position indicator on the front of the circuit breaker will display "CONN".









#### E. CIRCUIT BREAKER COMPARTMENT INTERFACES

### 1) Primary Disconnecting Devices

There are six primary disconnecting devices on the circuit breaker. They are arranged, two per phase, with the upper device connected to the stationary end of the vacuum interrupter, and the lower device connected to the moving end of the vacuum interrupter assembly. Each primary disconnecting device has multiple contact fingers which will mate with the stationary primary disconnecting devices in the circuit breaker compartment.

## **A CAUTION**

Do not handle or move the circuit breaker by the primary disconnecting devices as damage may occur.

### 2) Secondary Disconnecting Devices

Control power is transferred from the metal-clad switchgear to the circuit breaker by means of the secondary disconnect device. The secondary disconnect receptacle (Figure 3, m) is located on the bottom right side of the circuit breaker. The secondary disconnect plug is attached to the switchgear and is located on the right side wall of the circuit breaker compartment. This arrangement allows the secondary connection to be visible in all positions of the circuit breaker.

# 3) MOC (Mechanism Operated Cell Switch) Actuator

The MOC, located in the switchgear, is operated by a plunger which extends from the circuit breaker operating mechanism. Movement of the MOC actuator (Figure 3, q) is directly related to the movement of the circuit breaker mechanism and contacts.

## *4)* TOC (Truck Operated Cell Switch) Actuator

The TOC, located in the switchgear, is operated by circuit breaker truck position. To accomplish this, a TOC actuator (Figure 3, t) is located on the top left of the circuit breaker frame and it is designed to strike the TOC as the circuit breaker travels to the connected position.

#### 5) Ground Connection

The ground connection is an assembly of spring-loaded fingers that effectively grounds the circuit breaker frame as it is inserted into the circuit breaker compartment. The ground connection (Figure 3, y) is located at the rear edge of the floor pan of the circuit breaker centered on the middle pole of the circuit breaker. An extension of the metal-clad switchgear ground bus is secured to the circuit breaker compartment floor and engages the ground connection as the circuit breaker is placed into the disconnected position. The ground connection system remains engaged in all subsequent positions of the circuit breaker until the circuit breaker is removed from the compartment.



### 6) Shutter Rollers

The circuit breaker travels between the test/disconnected and connected positions as the crank arm rollers (Figure 3, ab) engage the vertical slots of the racking cams attached in the circuit breaker compartment. This action also drives the compartment shutters to open/close which allows the primary disconnecting devices to connect/disconnect. Downward movement of the crank arm rollers in the slots will move the shutters to the fully open position before the circuit breaker travels towards the connected position.

#### 7) Anti-Rollout Latch

To operate the anti-rollout latch (Figure 3, p), push the circuit breaker element forward in the compartment and depress the lever before pulling the circuit breaker element out of the compartment.

#### F. VACUUM INTERRUPTERS

PowlVac® circuit breakers utilize sealed vacuum interrupters to control the primary circuit. Some vacuum interrupters appear to be identical in size and shape externally, but types vary in ratings due to the differences in their internal construction. For a listing of the vacuum interrupters used in PowlVac-ND® Series 4 and PowlVac-NDA™ Series 4 circuit breakers see *Table E, Primary Current Path.* VACUUM INTERRUPTERS MUST BE REPLACED ONLY WITH NEW VACUUM INTERRUPTERS OF THE SAME PART NUMBER.

#### G. VACUUM INTERRUPTER CONNECTIONS

Connection to the vacuum interrupter stems is made by means of copper contact blocks. The top stem of the vacuum interrupter is threaded and a copper contact block is screwed onto this stem. The contact block is assembled to the upper primary disconnecting devices of the circuit breaker. Another copper contact block with primary disconnecting devices surrounds the bottom or moving stem of the vacuum interrupter. The sliding contact assembly inside the lower contact block makes contact with this block and the moving stem of the vacuum interrupter. The multiple parallel paths of the sliding contact assembly keeps the current density low.









### Ch 4 Installation

#### A. RECEIVING

When the circuit breaker is received check for any sign of damage. If damage is found or suspected, file all claims immediately with the transportation company and notify the nearest Powell representative.

Estimated size and weight for shipping a PowlVac-ND® Series 4 and PowlVac-NDA™ Series 4 circuit breaker on a pallet:

- Size: 42" width x 42" depth x 47" height
- · Weight: 400 lbs.

Figure 10 shows the circuit breaker enclosed in the carton used for shipment. The carton is attached to the shipping pallet by metal bands. Remove these bands and lift the carton from the pallet so that the circuit breaker is visible. The circuit breaker is attached to the pallet by metal shipping brackets. When these are removed the circuit breaker may be removed from the shipping pallet. Refer to Ch 4 Installation, B. Handling, for more information.

Figure 10 Circuit Breaker in Shipping Carton



When a metal-clad switchgear assembly is installed in a Power Control Room, a circuit breaker housed in the lower circuit breaker compartment may be shipped installed in the equipment. In these cases, the circuit breaker will be in the test/disconnected position and it will be bolted to the compartment floor by use of a shipping bracket. The horizontal leg of the bracket is bolted to the compartment floor and the vertical leg is bolted to the front of the circuit breaker using the lower cover bolts. Remove these four bolts, discard the shipping angle, and replace the four bolts.

#### B. HANDLING

After the circuit breaker has been removed from its shipping pallet it may be rolled on its own wheels on a level surface. This is the preferred way of handling the circuit breaker. When rolling the circuit breaker it should be pushed and steered by the steel frame or the front cover.

## **A CAUTION**

Do not handle or move the circuit breaker by the primary disconnecting devices as damage may occur.

If necessary, the circuit breaker can be moved by a fork lift truck or an overhead crane. When using a forklift truck take care to avoid components located under the circuit breaker floor pan. The forks on the truck should be set for a dimension over the forks of 18 inches. The forks should then ride under the wheel axles. The circuit breaker can also be lifted by an overhead crane using the two lifting holes which have been provided for hooks at the top of the circuit breaker frame side sheets (Figure 11).



Figure 11 Circuit Breaker on Crane



#### C. 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.

 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.









### D. PLACING THE CIRCUIT BREAKER INTO SERVICE

Before shipment from the factory, all circuit breaker functions are thoroughly checked. The user must verify functions after receipt. Powell recommends that the tests be performed in the following sequence:

1) High Voltage Insulation Integrity

## **A CAUTION**

High voltages across the open gaps of the vacuum interrupter can produce radiation. Personnel should stand at least one meter (3') away from the circuit breaker with the covers in place when conducting high voltage tests. Test voltage should not exceed 14.25kVAC (20kVDC) for circuit breaker with a rated maximum voltage of 4.76kV.

The primary circuit insulation on the circuit breaker may be checked phase-to-phase and phase-to-ground using a 2500V insulation resistance tester. Since definite limits cannot be given for satisfactory insulation values when testing with an insulation resistance tester, a record should be kept of the insulation resistance tester readings as well as the temperature and humidity readings. This record should be used to detect any weakening of the insulation system from one check period to the next.

To check insulation integrity, the AC high potential test described below is strongly recommended. DC testing is not the preferred method, however, values are provided due to the availability of DC test sets.

## **A CAUTION**

If DC high potential is performed, the DC high potential test machine must NOT produce instantaneous peak voltages exceeding 20kV.

The circuit breaker insulation should be tested with the circuit breaker vacuum interrupter contacts in the closed position. Test each pole of the circuit breaker separately, with the other 2 poles and the frame grounded. Perform the field dielectric test described in ANSI Standard C37.20.2, at the voltage level appropriate for the equipment. This test will have checked all of the primary phase-to-ground and phase-to-phase insulation.

Table A Field Dielectric Test Values		
Rated Maximum Voltage (kV rms)	Power Frequency Withstand (kV rms)	
4.76	14.25	

## **A CAUTION**

After the high potential is removed, an electrical charge may be retained by the vacuum interrupters. Failure to discharge this residual electrostatic charge could result in an electrical shock. All six primary disconnecting devices of the circuit breaker and the metallic mid band ring if present should be grounded and remain grounded for at least one minute to reduce this electrical charge before coming in to contact with the primary circuit.

## CAUTION

Remove all grounding conductors applied for this test before placing the circuit breaker back into service.



The tests described above are the only tests required to ascertain insulation integrity. Because of the design of the PowlVac insulation system, no valid data can be obtained utilizing other types of high voltage insulation tests.

2) Vacuum Integrity

### **A CAUTION**

Applying abnormally high voltage across a pair of contacts in vacuum may produce x-radiation. The radiation may increase with increased voltage and/or decreased contact spacing.

X-radiation produced during this test with the voltage specified in Table A and normal contact spacing is extremely low and well below the maximum permitted by standards.

Do NOT apply voltage that is higher than the recommended value. Do NOT use contact separation that is less than the normal open position separation of the circuit breaker contacts.

Powell recommends AC testing for reliable verification of vacuum integrity. All PowlVac-ND® and PowlVac-NDA™ Series 4 circuit breakers shall be tested with a minimum of 25kVAC applied across fully open contacts for 10 seconds. No dielectric breakdown during the test period constitutes a successful test.

Note: This test does not replace the AC high potential testing (Hipot) used to determine "High voltage insulation integrity." See Ch 4 Installation, D. Placing the Circuit Breaker Into Service, 1) High Voltage Insulation Integrity.

Powell offers a compact and lightweight **PowlVac** \*Vacuum Integrity Tester designed specifically for PowlVac \*circuit breakers. If this device is used refer to the instruction bulletin provided with the vacuum integrity tester.

Powell recognizes the widespread use of DC hipot equipment in the field and the desire to use this equipment to verify vacuum integrity. However, the capacitive component of the vacuum interrupter during DC testing may yield false negative test results, which are often misinterpreted as vacuum interrupter failure. When DC testing is performed, a test set providing a full wave rectified 35kV DC hipot voltage can be applied for 5 seconds as a "go - no go" test.

Recording the leakage readings is not necessary, as a dielectric breakdown will trip all portable DC hipot test sets. If a DC test breakdown occurs, the test must be repeated after reversing the DC high voltage test supply connection across the vacuum interrupter. A vacuum interrupter should be questioned only if it has failed both tests.

### **A CAUTION**

High voltages across the open gaps of the vacuum interrupter can produce x-radiation. When conducting high voltage test, personnel should stand at least one meter (3') away from the circuit breaker with the covers in place. Vacuum Integrity Test voltages should not exceed 25kVAC (35kVDC) for circuit breaker with a rated maximum voltage of 4.76kV.









### **A CAUTION**

When testing with DC, use a DC high potential test (hipot) set with full wave rectification. Many DC high potential test sets use half-wave rectification. Do NOT use these half-wave rectifiers. The capacitance of the vacuum interrupter in combination with the leakage currents in the rectifiers and its DC voltage measuring equipment may result in applying peak voltages as much as three times the measured voltage. These abnormally high voltages may give a false indication of a defective vacuum interrupter, and may produce abnormal x-radiation.

## **A CAUTION**

If DC high potential testing (hipot) is required, the DC high potential test machine must not produce instantaneous peak voltages exceeding 35kV.

No attempt should be made to try to compare the condition of one vacuum interrupter with another, nor to correlate the condition of any vacuum interrupter with low values of DC leakage current. There is no significant correlation.

### **A CAUTION**

After the high potential is removed, an electrical charge may be retained by the vacuum interrupters. Failure to discharge this residual electrostatic charge could result in an electrical shock. All six primary disconnecting devices of the circuit breaker and the metallic mid band ring, if present, should be grounded and remain grounded for at least one minute to reduce this electrical charge before coming into contact with the primary circuit.

#### 3) Control Voltage Insulation Integrity

If the user wishes to check the insulation integrity of the control circuit, it may be done with a 500V or 1000V insulation resistance tester or with an AC high potential tester. The AC high potential test should be made at 1125V, 50 or 60 Hz for one minute. The charging motor must be disconnected prior to testing the control circuit. The charging motor itself may be similarly tested at a voltage not to exceed 675V, 50 or 60 Hz. Be sure to remove any test jumpers and reconnect the charging motor when the tests are complete.

## CAUTION

Remove all grounding conductors applied for this test before placing the circuit breaker back into service.



#### 4) Mechanical Operation Check

## **A CAUTION**

Keep personnel, tools, and other objects clear of mechanisms that are to be operated or released. Failure to do so may result in equipment damage and/or minor or moderate injury.

The contacts of the vacuum interrupter during normal operation cannot be closed unless the secondary disconnect plug is inserted into the secondary disconnect receptacle. To check the circuit breaker outside of the circuit breaker compartment, it is necessary to simulate the connection of secondary disconnecting device by inserting the secondary disconnect override device in the secondary disconnect receptacle. This device must be removed after testing and before the circuit breaker is inserted into the compartment. The mechanical operation of the circuit breaker is checked by inserting the manual charging handle into the manual charging crank and pushing down until a metallic click is heard (this indicates that the holding pawl has dropped into place on the ratchet wheel). Lift the handle until it is horizontal and then depress. The procedure is repeated until the spring charge indicator indicates "CLOSING SPRING CHARGED". This requires about 60 operations of the handle. Once the closing spring is charged, remove the handle.

## **A CAUTION**

The MOC actuator is exposed when the circuit breaker is outside the metal-clad switchgear and can cause serious injury if the test personnel or any object is in the travel path during operation. Care should be taken to isolate the MOC side of the circuit breaker for these tests.

Push the manual close operator (Figure 3, I) inward and the circuit breaker will close. The circuit breaker open/closed indicator located above the manual close operator will now display "BREAKER CLOSED". Push the manual trip operator (Figure 3, h) inward, which is located at the top of the escutcheon and the circuit breaker open/closed indicator will now display "BREAKER OPEN".









#### *5) Electrical Operation Check*

To check the basic electrical operation of the circuit breaker, a circuit breaker test cabinet must be used. Connect the secondary disconnect from the test cabinet to the circuit breaker to be tested. The test cabinet provides control voltage via a secondary disconnect plug to the circuit breaker and the appropriate control switches to verify the close and open functions of the circuit breaker. Specialized versions of the test cabinet may also contain circuits for circuit breakers equipped with dual shunt trip coils, undervoltage devices, or other options. With the secondary disconnect plug installed in the circuit breaker under test, operate the power switch on the test cabinet. The charging motor will automatically charge the stored energy mechanism's main closing springs. Operation of the control switch on the front door of the test cabinet to the "close" position will cause the circuit breaker to close.

The circuitry is arranged to cause the charging motor to operate again and charge the main closing spring. Operating the control switch on the front door of the test cabinet to the "open" position will cause the circuit breaker to open.

Alternatively, a test jumper cable may be used to electrically operate the circuit breaker using the control circuitry of the circuit breaker compartment. Caution must be exercised if this option is chosen to ensure that operation of the control circuitry of the compartment used for test does not cause undesirable effects or unintended operation of other interconnected equipment such as supervisory controls, SCADA, or automatic transfer schemes.

First, remove the control fuses in the compartment. Connect the jumper cable to the secondary disconnect plug in the compartment and to the circuit breaker. Insert the fuses. The charging motor will automatically charge the stored energy mechanism's main closing springs. Operation of the breaker control switch on the front door of the compartment will cause the circuit breaker to close. The circuitry is arranged to cause the charging motor to operate again and charge the main closing spring. Operating the breaker control switch on the front door will cause the circuit breaker to open.

6) Emergency Racking Mechanism Check (PowlVac-NDA™ Series 4 Circuit Breaker Only)

The emergency racking mechanism may be checked outside the circuit breaker compartment.

The emergency racking drive shaft can be accessed by moving the emergency racking drive shaft shutter (*Figure 3, b*) downward.

**Note:** The emergency racking drive shaft shutter cannot be moved downward unless the circuit breaker is open.

Insert the racking handle onto the racking drive shaft. The racking crank arms (Figure 3, ad) at the sides of the circuit breaker should be in the fully withdrawn position and point towards the primary disconnecting devices.



The breaker position indicator on the front of the circuit breaker should display, "TEST". Rotate the racking handle in a counterclockwise direction. The racking crank arms will move downward and rotate until the breaker position indicator displays "CONN". Stop bolts on the side sheet of the breaker prevent further rotation of the racking drive shaft. Once the breaker position indicator displays "CONN", the racking mechanism will have reached the end of its travel and a significant increase in the amount of resistance encountered will indicate that further force should not be exerted. Once factory torque limits are reached a torque limiting clutch on the racking handle will engage and disallow any further racking. In this position, the racking handle may be removed from the racking drive shaft and the racking drive shaft shutter will spring back to the closed position.

Once again, depress the racking drive shaft shutter, insert the racking handle and rotate in a clockwise direction until the racking crank arms are once more in the fully withdrawn position and the breaker position indicator displays "TEST".

### **A CAUTION**

Pole unit parts are energized at full circuit voltage when the circuit breaker is in the connected position. Prior to moving the circuit breaker into the connected position, make sure that the main barrier assembly has been properly fastened in place. Failure to do so may cause equipment damage and/or minor or moderate injury.

## E. RACKING PROCEDURES FOR POWLVAC-ND® SERIES 4 CIRCUIT BREAKER

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

## **NOTICE**

To insert the circuit breaker into the upper compartment a lifting device must be used. Refer to the Lifting Device instruction bulletin for details on how to insert a circuit breaker into the upper compartment.

## NOTICE

Be sure that the racking crank arms at the sides of the circuit breaker point in the direction of the primary disconnecting devices and the circuit breaker position indicator displays breaker test/disconnected.

Each circuit breaker and circuit breaker compartment is provided with interference plates which are designed to ensure that no circuit breaker with less than the required voltage, continuous current, or interrupting current rating is placed in the incorrect circuit breaker compartment. If you attempt to insert an improperly rated circuit breaker into the circuit breaker compartment, these plates will interfere with each other and deter further insertion. The interference will occur before the circuit breaker reaches the disconnected position. Do not attempt to force the circuit breaker past the compartment interference plate or remove the interference plates from either the compartment or the circuit breaker.









Remove the incorrectly rated circuit breaker and insert a properly rated circuit breaker into the circuit breaker compartment.

- Prior to Inserting the Circuit Breaker into the Circuit Breaker Compartment
  - a. Check the Primary Disconnecting Devices and Circuit Breaker Compartment

Examine the primary disconnecting devices for any signs of damage and contamination. Check to see that none are bent out of alignment. If contamination is found refer to Ch 5 Maintenance, A. General Description, 2) Inspection and Cleaning and Ch 5 Maintenance B. Mechanism Area, 2) Lubrication for cleaning and lubrication procedures. If the primary disconnecting devices are damaged make no attempt to repair. Contact Powell for further information.

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

## **CAUTION**

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

## **CAUTION**

Before inserting a circuit breaker into the circuit breaker compartment, be sure that the indicator flag on the front cover of the circuit breaker displays "TEST".

# b. Racking the Circuit Breaker into the Circuit Breaker Compartment

The described racking procedures apply only for the PowlVac-ND® Series 4 circuit breakers. For all other constructions, refer to the appropriate instructions or instruction bulletin(s) for the applicable racking procedures.

The PowlVac-ND Series 4 circuit breaker may be racked manually or electrically using the optional Power Racking device.

The PowlVac-ND Series 4 circuit breaker is designed to be manually racked into the circuit breaker compartment with the compartment door closed. The optional Power Racking device may be fitted on the closed circuit breaker compartment door to eliminate manual operation.

**Note:** The described racking procedures are for racking the circuit breaker into the lower circuit breaker compartment only. To rack the circuit breaker into an upper circuit breaker compartment, refer to the metal-clad switchgear instruction bulletin for detailed information.



## **CAUTION**

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

### **CAUTION**

Before inserting a circuit breaker into the circuit breaker compartment, be sure that the indicator flag on the front cover of the circuit breaker displays "TEST".

### **CAUTION**

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

## NOTICE

The illustrations shown for all racking procedures are provided to show device locations and are intended only as a guideline. These illustrations may not be representative of site specific safety practices for performing the procedure. Before attempting any racking procedure, review Chapter 2.

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

## **NOTICE**

To insert the circuit breaker into the upper compartment a lifting device must be used. Refer to the Lifting Device instruction bulletin for details on how to insert a circuit breaker into the upper compartment.

## **A CAUTION**

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

## **CAUTION**

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

- 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.







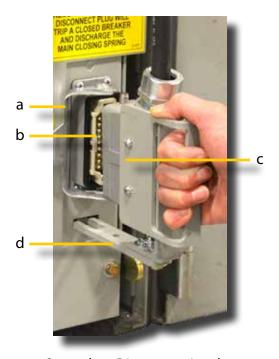


c. Roll the circuit breaker into the compartment until the racking crank arms make contact with the vertical slots in the compartment. The anti-rollout latch under the circuit breaker will engage the block in the compartment, preventing accidental removal of the circuit breaker from the compartment.

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

d. Insert the circuit breaker compartment's secondary disconnect plug (Figure 12, c) into the circuit breaker's secondary disconnect receptacle (Figure 12, b). Once the plug is fully inserted, move the secondary disconnect latch (Figure 12, a) from left to right until it has engaged the housing of the secondary disconnect plug.

Figure 12 Secondary Disconnect Device



- a. Secondary Disconnect Latch
- b. Secondary Disconnect Receptacle
- c. Secondary Disconnect Plug
- d. Interlock Bar

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

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.

- 3) Inserting the Circuit Breaker to the Connected Position
  - a. Insert the racking handle onto the racking drive shaft extension (Figure 13).

Figure 13 Racking Handle Insertion



- a. Racking Handle
- b. Racking Handle Socket



b. Turning the racking handle clockwise will begin to rack the circuit breaker into the compartment. 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 with 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 "CONN" as observed through the compartment door view window. This will be approximately 22 rotations from the starting point. When the circuit breaker reaches the end of the racking travel, the operator will notice an increased amount of force. If the user continues to apply force, a torque limiter on the racking handle will produce an audible 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 racking mechanism.

c. Once the circuit breaker has reached the connected position remove the racking handle, and operate the circuit breaker as required.

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

4) Removing the Circuit Breaker from the Connected to the Test/Disconnected Position

## **A CAUTION**

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

## **A 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" and if not, operate the circuit breaker control switch to open the circuit breaker.
- b. Place the racking handle socket onto the racking drive shaft extension.
- Turn the racking handle counterclockwise until the breaker position indicator displays "TEST".
- d. Remove the racking handle. This is approximately 22 turns from the "CONN" position.

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









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

## **A CAUTION**

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

## **A 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. Lift the secondary disconnect latch and remove the circuit breaker compartment's secondary disconnect plug. Store the plug so it will not be damaged while withdrawing the circuit breaker.

### **A CAUTION**

Removal of the secondary disconnect plug will trip a closed breaker and discharge the main closing spring.

c. Press the anti-rollout latch downward to release the circuit breaker and pull the circuit breaker out of the circuit breaker compartment (Figure 14, a).

Figure 14 Circuit Breaker Anti-Rollout Latch



a. Anti-Rollout Latch

### 6) Remote Racking

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 when the circuit breaker is racked with the compartment door closed. Refer to the instruction bulletin provided with the Remote Racking Device for the proper operational procedure.



# F. RACKING PROCEDURES FOR POWLVAC-NDA™ SERIES 4 CIRCUIT BREAKER

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

## NOTICE

To insert the circuit breaker into the upper compartment a lifting device must be used. Refer to the Lifting Device instruction bulletin for details on how to insert a circuit breaker into the upper compartment.

## NOTICE

Be sure that the racking crank arms at the sides of the circuit breaker point in the direction of the primary disconnecting devices and the circuit breaker position indicator displays breaker test/disconnected.

Each circuit breaker and circuit breaker compartment is provided with interference plates which are designed to ensure that no circuit breaker with less than the required voltage, continuous current, or interrupting current rating is placed in the incorrect circuit breaker compartment. If you attempt to insert an improperly rated circuit breaker into the circuit breaker compartment, these plates will interfere with each other and deter further insertion. The interference will occur before the circuit breaker reaches the disconnected position. Do not attempt to force the circuit breaker past the compartment interference plate or remove the interference plates from either the compartment or the circuit breaker. Remove the incorrectly rated circuit breaker and insert a properly rated circuit breaker into the circuit breaker compartment.

- 1) Prior to Inserting the Circuit Breaker into the Circuit Breaker Compartment
  - a. Check the Primary Disconnecting Devices and Circuit Breaker Compartment

Examine the primary disconnecting devices for any signs of damage and contamination. Check to see that none are bent out of alignment. If contamination is found refer to Ch 5 Maintenance, A. General Description, 2) Inspection and Cleaning and Ch 5 Maintenance B. MECHANISM AREA, 2) Lubrication for cleaning and lubrication procedures. If the primary disconnecting devices are damaged make no attempt to repair. Contact Powell for further information.

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

### **CAUTION**

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

## **CAUTION**

Before inserting a circuit breaker into the circuit breaker compartment, be sure that the indicator flag on the front cover of the circuit breaker displays "TEST".









# b. Racking the Circuit Breaker into the Circuit Breaker Compartment

The described racking procedures apply only for the PowlVac-NDA™
Series 4 circuit breakers. For all other constructions, refer to the appropriate instructions or instruction bulletin(s) for the applicable racking procedures.

The PowlVac-NDA circuit breaker is designed to be electrically racked into the circuit breaker compartment from a remote location with the compartment door closed. The PowlVac-NDA circuit breaker may also be manually racked using the emergency override option with the compartment door open.

**Note:** The described racking procedures are for racking the circuit breaker into the lower circuit breaker compartment only. To rack the circuit breaker into an upper circuit breaker compartment, refer to the metal-clad switchgear instruction bulletin for detailed information.

### **CAUTION**

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

## **CAUTION**

Before inserting a circuit breaker into the circuit breaker compartment, be sure that the indicator flag on the front cover of the circuit breaker displays "TEST".

## **CAUTION**

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

## NOTICE

The illustrations shown for all racking procedures are provided to show device locations and are intended only as a guideline. These illustrations may not be representative of site specific safety practices for performing the procedure. Before attempting any racking procedure, review Chapter 2.

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

## NOTICE

To insert the circuit breaker into the upper compartment a lifting device must be used. Refer to the Lifting Device instruction bulletin for details on how to insert a circuit breaker into the upper compartment.

## **A CAUTION**

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



## **CAUTION**

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

- 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 into the compartment until the position interlock bar and roller contacts a positive stop.

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

d. Insert the circuit breaker compartment's secondary disconnect plug into the circuit breaker's secondary disconnect receptacle. Once the plug is fully inserted, move the secondary disconnect latch from left to right until it has engaged the housing of the secondary disconnect plug.

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

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.

3) Inserting the Circuit Breaker to the Connected Position

## NOTICE

The preferred method of racking the NDA circuit breaker is electrically from a remote location via Sentry remote controller. Refer to the instruction bulletin provided with the controller for detailed information on the automatic racking procedures.

4) Emergency Racking In Procedure

## NOTICE

In the event of an emergency, such as loss of control power, the NDA circuit breaker is equipped with an emergency racking mechanism which enables racking the circuit breaker into or out of the connected position.

The following emergency racking procedure is intended to be used only in the event of loss of control power, or failure of the Sentry remote controller, or circuit breaker to operate electrically.

For instructions on inserting the circuit breaker into the compartment refer to Ch 4 Installation, F. Racking Procedures for PowlVac-NDA™ Series 4 Circuit Breaker, 2) 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 connected position, remove the padlock seal (Figure 3, d), open the emergency racking drive shaft shutter (Figure 3, b) and place the racking handle socket onto the emergency racking drive shaft. The racking handle socket may be used to push down the shutter to gain access to the racking drive shaft.
- c. Turning the racking handle counterclockwise will begin to rack the circuit breaker into the compartment. 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 with 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 "CONN". 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 racking mechanism.
- d. Once the circuit breaker has reached the connected position, remove the racking handle, visually verify the emergency racking drive shaft shutter has returned to its normal position, close the compartment door, and operate the circuit breaker as required.

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

 Removing the Circuit Breaker from the Connected to the Test/Disconnected Position

## **A CAUTION**

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

### **A 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.

## NOTICE

The preferred method of racking the NDA circuit breaker is electrically from a remote location via Sentry remote controller. Refer to the instruction bulletin provided with the controller for detailed information on the automatic racking procedures.



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

## **A CAUTION**

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

## **A 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. Push the secondary disconnect latch (Figure 12, a) to the left. This will unlock the secondary disconnect plug, allowing it to be removed. Remove the secondary disconnect plug.

## **A CAUTION**

Removal of the secondary disconnect plug will trip a closed breaker and discharge the main closing spring.

c. Press the anti-rollout latch (Figure 14, a) to release the circuit breaker and pull the circuit breaker out of the circuit breaker compartment.

6) Emergency Racking Out Procedure

# NOTICE

In the event of an emergency, such as loss of control power, the NDA circuit breaker is equipped with an emergency racking mechanism which enables racking the circuit breaker into or out of the connected position.

## **A CAUTION**

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

- To remove the circuit breaker from the Connected position to the Test/Disconnect position perform the following:
  - Verify that the circuit breaker open/closed indicator displays "BREAKER OPEN". If "CLOSED", operate the circuit breaker control switch to open the circuit breaker.
  - 2. Open the compartment door. If the padlock seal is present, remove the seal (Figure 3, d). Open the emergency racking drive shaft shutter (Figure 3, b) and place the racking handle socket onto the emergency racking drive shaft. The racking handle socket may be used to push down the shutter to gain access to the racking drive shaft.









- Turn the racking handle clockwise until the breaker position indicator displays "TEST".
- 4. Remove the racking handle and verify that the emergency racking drive shaft shutter has returned to its normal position.

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

- b. To remove the circuit breaker from the Test position out of the circuit breaker perform the following:
  - 1. Push the secondary disconnect latch (Figure 12, a) to the left. This will unlock the secondary disconnect plug, allowing it to be removed. Remove the secondary disconnect plug.

## **A CAUTION**

Removal of the secondary disconnect plug will trip a closed breaker and discharge the main closing spring.

- 2. Press the anti-rollout latch (Figure 14, a) to release the circuit breaker and pull the circuit breaker out of the circuit breaker compartment using the handles.
- 3. Once the circuit breaker has been removed and service has been performed, replace the padlock seal.



#### Ch 5 Maintenance

## **A CAUTION**

Prior to beginning any maintenance procedures make certain that the control circuits are deenergized and the circuit breaker is resting securely outside the circuit breaker compartment. Do NOT work on a closed circuit breaker or a circuit breaker with the main closing spring charged.

## **NOTICE**

Before attempting any maintenance work, it is important to study and fully understand the safety practices outlined in Ch 2 Safety of this instruction bulletin. If there is any reason to believe there are discrepancies in the descriptions contained in this instruction bulletin, or if they are deemed to be confusing and/or not fully understood, contact Powell immediately.

#### A. GENERAL DESCRIPTION

#### 1) Introduction

A regular maintenance schedule must be established to obtain the best service and reliability from the circuit breaker.

PowlVac-ND® and PowlVac-NDA™ Series
4 circuit breakers are designed to comply with industry standards requiring maintenance every 1000 or 2000 operations depending upon the rating of the circuit breaker, or once a year.

Actual inspection and maintenance will depend upon individual application conditions such as number of operations, magnitude of currents switched, desired overall system reliability, and operating environment. Any time the circuit breaker is known to have interrupted a fault current at or near its rating, it is recommended that the circuit breaker be inspected and the necessary maintenance be performed as soon as practical. Some atmospheric conditions such as extremes of dust, moisture, or corrosive gases might indicate inspection and maintenance at more frequent intervals. Very clean and dry conditions combined with low switching duty will justify longer times between inspection and maintenance operations. With experience, each user can set an inspection and maintenance schedule that is best suited for use.

If maintenance is performed at longer time intervals than one year, the vacuum integrity test should be performed each time the circuit breaker is removed from the metal-clad switchgear for reasons other than scheduled circuit breaker maintenance if it has been more than one year since the last vacuum integrity test.

A permanent record of all maintenance work should be kept, the degree of detail depending upon on the operating conditions. The record will be a valuable reference for subsequent maintenance work and for station operation. It is also recommended that the record include reports of tests performed, the condition of circuit breakers, and any repairs or adjustments that were performed. This record should begin with tests performed at the time of installation and energization, and all data should be graphed as a function of time to ensure a proper maintenance cycle is being scheduled.









Because of extensive quality control tests made at the factory, the operations counter on a new circuit breaker will normally register over hundred operations. The reading of the operations counter should be recorded when the circuit breaker is placed into service and when any maintenance work is performed.

### **A CAUTION**

When any maintenance procedure requires opening or closing of the circuit breaker or charging of any of the mechanism springs, exercise extreme care to make sure that all personnel, tools, and other miscellaneous objects are kept well clear of all moving parts or charged springs.

2) Inspection and Cleaning

### **A CAUTION**

When cleaning the circuit breaker insulating supports and bus insulation, use only denatured alcohol or isopropyl alcohol to remove foreign material. Failure to do so may damage the dielectric and/or the mechanical properties of the insulation.

Visually check the circuit breaker for loose or damaged parts. Tighten or replace loose or missing hardware. Any damaged parts that will interfere with the normal operation of the circuit breaker should be replaced. This inspection will be much easier if the front cover and interphase barriers are removed.

Clean the circuit breaker by removing any loose dust and dirt. Do not use compressed air to clean the circuit breaker. This may result in loose dirt or grit being blown into bearings or other critical parts, thus causing excessive wear. Use a vacuum cleaner, or wipe with a dry lint-free cloth or an industrial-type wiper to clean the circuit breaker. Do not use solvents, degreasers, or any aerosol products to clean in the area of any mechanisms.

Primary insulation, including the vacuum interrupter supports and the operating pushrods, should be cleaned. Wipe clean with a dry lint-free cloth or an industrial type wiper. If dirt adheres and cannot be removed by wiping, remove it with distilled water or a mild solvent such as denatured alcohol. Be sure that the circuit breaker is dry before returning it to service. Do not use any type of detergent to wash the surface of the insulators as detergent may leave an electrically conducting residue on the surface as it dries.



#### B. MECHANISM AREA

### **WARNING**

When any maintenance procedure requires the opening or closing of the circuit breaker or the charging of any of the stored energy mechanism springs, exercise extreme caution to make sure that all personnel, tools, and other miscellaneous objects are kept well clear of the moving parts or the charged springs. Failure to do this may cause damage to the equipment or moderate/minor injury to personnel.

#### 1) Mechanical Operation

Remove the circuit breaker front cover to expose the stored energy mechanism. Make a careful visual inspection of the mechanism for loose, damaged or excessively worn parts.

Note: If timing tests under
Ch 5 Maintenance, D. Optional
Maintenance Procedures are to
be performed do not operate the
circuit breaker until these tests
are completed. Operation of the
mechanism may alter the "As found"
operating condition of the circuit

breaker's stored energy mechanism.

Operate the racking mechanism through one or two complete cycles and check for the smoothness of operation. It will be necessary to insert the secondary disconnect override device into the secondary disconnect receptacle to perform this operation.

For further details see *Ch 4 Installation, D. Placing the Circuit Breaker Into Service, 4) Mechanical Operation Check* &

Ch 4 Installation, D. Placing the Circuit Breaker Into Service 6) Emergency Racking Mechanism Check (PowlVac-NDA™ Series 4 Circuit Breaker Only).

#### 2) Lubrication

## **CAUTION**

Before applying any type of lubrication to the circuit breaker, the stored energy mechanism should be in the OPEN position, and all springs discharged.

Powell offers a complete lubrication kit (Powlube-104) which contains all the lubricants required for maintaining the circuit breakers. 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. Lubricate the stored energy mechanism and other specified parts in accordance with *Table B, Lubrication*. See *Figures 15 & 16* for labeled lubrication photographs.

Table B, Lubrication lists the location of all surfaces that should be lubricated, the type of lubricant to be used, and the method of applying the lubricant. The guiding rule in lubrication is to lubricate regularly, use lubricant sparingly and remove all excess lubricant. Tilting the circuit breaker will enable the lubricant to cover the bearing surfaces.







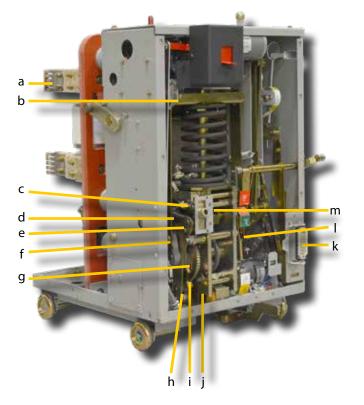


Table B Lubrication					
Location	Reference Figure	Lubricant	Method		
Electrical Parts					
Primary Disconnecting Device	Figure 15, a	B - Grease	Wipe clean. Apply lubricant only to actual contact surface.		
Ground Connection	Figure 16, t	B - Grease	Wipe clean. Apply lubricant only to actual contact surface.		
Secondary Disconnect Receptacle	Figure 15, k	B - Grease	Wipe clean. Apply lubricant only to actual contact surface.		
Mechanical Parts					
Spring Yoke Pin	Figure 15, b	C - Oil			
Trip Shaft Bearing	Figure 15, c	C - Oil			
Jackshaft Support	Figure 15, d	C - Oil			
Pawl Support Arm	Figure 15, e	C - Oil			
Crank Pin	Figure 15, f	C - Oil			
Motor Drive Shaft Roller Needle Bearings	Figure 15, h	C - Oil			
Pawls	Figure 15, i	C - Oil			
Close Latch Shaft Face	Figure 15, j	A - Grease	Apply a light coating of grease and remove all excess.		
Ratchet Wheel	Figure 15, g	A - Grease			
Jackshaft Lever Pins passing through Operating Pushrods	Figure 15, l	C - Oil	Avoid lubricating on operating pushrods.		
Fundamental Linkage Pin	Figure 15, m	C - Oil	Apply to penetrate where pin passes through end link.		
Main Closing Spring Guide Rod	Figure 16, n	C - Oil			
Racking Mechanism	Figure 16, o	C - Oil A - Grease	Apply C - Oil to the crank arm rollers and racking crank arms. Wipe clean. Apply A - Grease to worm gear.		
Primary Trip Prop	Figure 16, p	C - Oil			
Open-Close Flag Drive Lever Pin at Jackshaft	Figure 16, q	C - Oil			
Flag Support Pin	Figure 16, r	C - Oil			
Jackshaft Outer Bearing Support	Figure 16, s	C - Oil			
Motor Drive Shaft Coupling	Figure 16, u	C - Oil			
Wheel	Figure 16, v	C - Oil			
Motor Drive Shaft Support Bearings	Figure 16, w	C - Oil			
Camshaft Needle Bearings	Figure 16, x	C - Oil			
Close Shaft Support Bearing	Figure 16, y	C - Oil			
Motor Cutoff Cam	Figure 16, z	A - Grease	Apply to peripheral surface only.		
Fundamental Linkage	Figure 16, aa	C - Oil	Apply to penetrate where pins pass through lines.		
Racking Drive Shaft Extension (PowlVac-ND® Only)	Figure 16, ab	A - Grease	Wipe clean. Extend and apply A- Grease to the exposed surface.		

**Note:** 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 456. See Ch 5 Maintenance, B. Mechanism Area, 2) Lubrication for more details.



### Figure 15 Lubrication





a. Primary Disconnecting Device



b. Spring Yoke Pin



c. Trip Shaft Bearing



d. Jackshaft Support



e. Pawl Support Arm



f. Crank Pin



g. Ratchet Wheel



h. Motor Drive Shaft Roller Needle Bearings



i. Pawls



j. Close Latch Shaft Face



k. Secondary Disconnect Receptacle



I. Jackshaft Lever Pin



m. Fundamental Linkage Pin



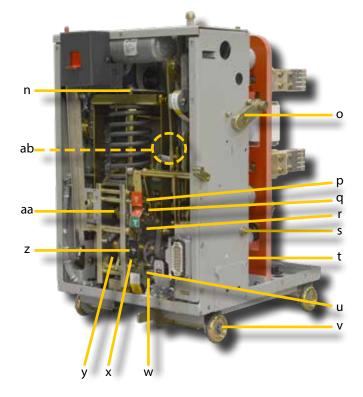








Figure 16 Lubrication (cont)





n. Main Closing Spring Guide Rod



o. Racking Mechanism



p. Primary Trip Prop



q. Open-Closed Flag Drive Lever Pin at Jackshaft



r. Flag Support Pin



s. Jackshaft Outer Bearings Support



t. Ground Connection



u. Motor Drive Shaft Coupling



v. Wheel



w. Motor Drive Shaft Support Bearings



x. Camshaft Needle Bearings



y. Close Shaft Support Bearing



z. Motor Cutoff Cam



aa. Fundamental Linkage



ab. Racking Drive Shaft Extension (PowlVac-ND® Only)



#### *3)* Closing Spring Removal

The closing spring must be removed in order to perform the slow closing of mechanism.

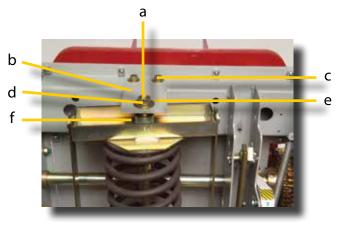
Although main closing spring removal is not necessary for lubrication, it may be necessary for performing adjustments or major overhaul tasks. Furthermore, removal of the main closing spring permits slow closing of the mechanism and the vacuum interrupter contacts. For details, see *Ch 5 Maintenance*, *B. Mechanism Area*, *4) Slow Closing of Mechanism*.

The procedure for spring removal is as follows:

- 1. With the main closing spring discharged and the circuit breaker contacts open, remove the bolt at the top of the spring rod together with the flat washer and lock washer (Figure 17).
- 2. Remove the horizontal bracket at the top of the main closing spring by unfastening the two attachment bolts (Figure 17, c).
- 3. Remove the spacer from above the bracket.
- 4. Turn the bracket 90°, and replace it on the top of the spring yoke (*Figure 18, a*).
- 5. Place the spacer below the bracket with the flat washer below it.
- 6. Insert bolt and tighten until the tension is taken off the connecting rods (Figure 18).
- 7. With a slight rocking motion of the main closing spring assembly, the connecting rods (Figure 18, d) can now be unhooked from the spring yoke pins and the main closing spring assembly can be removed.

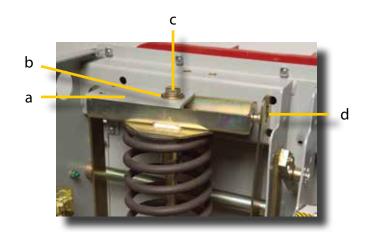
**Note:** Care should be taken on reassembly to ensure correct location of the flat washer, lock washer and spacer.

Figure 17 Main Closing Spring Assembly Installed



- a. Bolt
- b. Bracket
- c. Attachment Bolt (2)
- d. Lock Washer
- e. Flat Washer
- f. Spacer

Figure 18 Main Closing Spring Assembly Compressed for Removal



- a. Bracket
- b. Flat Washer
- c. Bolt
- d. Connecting Rod









#### 4) Slow Closing of Mechanism

The slow closing of mechanism described is not required for routine maintenance; however, it may be a useful procedure for troubleshooting circuit breaker misoperation.

For slow closing of mechanism, perform the following steps:

- With the main closing spring assembly removed, rotate the camshaft so that the crank arms are pointing upward. The fundamental linkage will now move into the reset position.
- Push the manual close operator inward and hold it in while operating the manual charging handle to rotate the camshaft.
- 3. When the close release latch arm is past the close shaft latch plate, the manual close operator may be released. As the main closing cam engages the main cam roller, the jackshaft will commence to rotate.
- 4. Continue to operate the charging handle until the crank arms point downward. The circuit breaker will now be closed and there will be a gap between the operating pushrod lock nuts and the contact spring yokes.
- Return the circuit breaker to the open position by depressing the manual trip operator.
- 6. To install the main closing spring assembly reverse the steps in Ch 5 Maintenance, B. Mechanism Area, 3) Closing Spring Removal.

**Note:** Even though the mechanism was "slow closed", when it is opened, it will operate at full speed, keep all fingers and toes out of the way, etc.

#### 5) Mechanism Adjustments

Several factory adjustments in the stored energy mechanism are described below. NO ADJUSTMENT OF THESE SETTINGS IS REQUIRED FOR ROUTINE MAINTENANCE, but they may need to be adjusted after a major overhaul or removal of the mechanism.

## **CAUTION**

Do NOT adjust these settings unnecessarily as damage to the circuit breaker may occur.

### a. Adjustment of Ratchet Wheel Holding Pawl

The holding pawl support arm is adjusted by the holding pawl adjusting eccentric (*Figure 4, t*).

If the pawl is not properly adjusted, there will be a "knocking" noise when the ratchet mechanism is operating or the stored energy mechanism will not ratchet at all.

To adjust the pawl perform the following steps:

- Remove the escutcheon to gain access to the head of the bolt holding the adjusting eccentric.
- 2. Loosen the bolt slightly.
- 3. Grip the eccentric with a pair of slip-joint pliers or a similar tool and rotate the stop slightly.
- 4. Tighten the holding bolt with the eccentric in the new position.
- While charging the main closing springs, using the charging motor to drive the mechanism, observe the ratcheting operation for improvement.

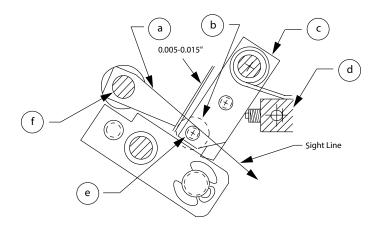


- 6. If the ratcheting operation has not improved, repeat the preceding sequence until the ratcheting operation is smooth. This may require several charging cycles.
- 7. When the eccentric is properly set replace the escutcheon.

Be sure that the escutcheon is reinstalled on the proper circuit breaker, since the escutcheon contains the nameplate with the circuit breaker's rating and serial number information. The serial number of the circuit breaker is also attached to the circuit breaker frame near the ground connection on a stamped metal plate. The serial number found on the nameplate must match the number affixed to the frame.

#### b. Adjustment of Primary Trip Prop

Figure 19 Primary & Secondary Trip Prop Adjustment



- a. Secondary Trip Prop (Top Edge)
- b. Primary Trip Prop Roller
- c. Primary Trip Prop
- d. Primary Trip Prop Adjusting Screw
- e. Rivet
- f. Trip Bar

Perform the following procedures to adjust the primary trip prop:

- Remove the main closing spring.
   Refer to Ch 5 Maintenance,
   Mechanism Area, 3) Closing Spring Removal.
- 2. Adjust the primary trip prop adjusting screw (Figure 19, d) so that with the fundamental linkage in the reset position, the clearance between the primary trip prop roller and the secondary trip prop is 0.005" to 0.015". The primary trip prop adjusting screw is accessible through the slot in the top of the lower insulator support channel, using an allen socket hex key wrench.
- 3. Replace the main closing spring.

#### c. Tripping System Adjustment

To adjust the PowlVac® Tripping System perform the following steps:

### **A 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.

- 1. Remove the circuit breaker front cover.
- 2. Loosen the secondary trip prop adjusting screw (Figure 21, c) locking nut several full turns.









### **CAUTION**

Do not allow the secondary trip prop adjusting screw to turn while loosening the locking nut. Failure to observe this caution will severely damage the mechanism.

- 3. Manually charge the circuit breaker main spring.
- 4. Manually CLOSE the circuit breaker.
- 5. Slowly turn the secondary trip prop adjusting screw clockwise in ½ turn (45°) increments until the breaker trips (OPENS). Carefully note the rotational position of the tool used to turn the adjusting screw at the moment the breaker operates. DO NOT turn the screw any further clockwise after the breaker operates.
- 6. Turn the secondary trip prop adjusting screw counterclockwise 1 ½ full turns from the position noted in *step 5*.
- 7. While holding the secondary trip prop adjusting screw from turning, securely tighten the secondary trip prop adjusting screw locking nut.
- 8. Manually charge the main closing spring using the manual charge handle per Ch 4 Installation,
  D. Placing the Circuit Breaker Into Service, 4) Mechanical Operation Check.
- 9. Manually CLOSE the circuit breaker.
- 10. Using leaf type feeler gauges with a total of 0.090" thickness selected, position the feeler gauge (Figure 20).

Figure 20 Feeler Gauge



11. Slowly depress the trip coil armature using the manual charge handle.

Depress the handle until the armature contact the feeler gauges.

The circuit breaker should NOT trip.

**Note:** Tilting the armature by applying a load to the right of the feeler gauges will produce incorrect results.

- 12. Choose one of the following steps according to the TRIP status:
  - i. If the circuit breaker TRIPPED during the test performed in *step 11*, increase the gap between the trip coil armature and the trip lever by bending the lever downwards slightly using channel lock pliers or a small crescent wrench. Repeat *steps 8 through 11*.

**Note:** Bend the trip lever in very small increments. This process may take several attempts.

ii. If the circuit breaker did not TRIP during the test performed in *step* 11, reset the feeler gauges with 0.030" selected.



13. Slowly depress the trip coil armature using the manual charge handle.

Depress the handle until the armature contacts the feeler gauges.

The circuit breaker should trip.

**Note:** It is important to avoid "tilting" the trip coil armature. Tilting the armature by applying a load to the right of the feeler gauges will produce incorrect results.

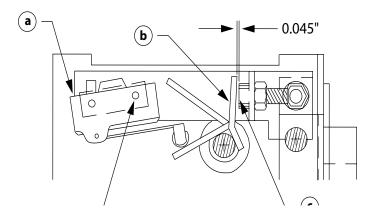
14. If the circuit breaker did NOT TRIP during the test performed in *step 14*, remove the feeler gauges and trip the breaker. Decrease the gap between the trip coil armature and the trip lever by bending the trip lever upwards slightly using channel lock pliers or a small crescent wrench. Repeat *steps 8, 9, & 13*.

**Note:** Bend the trip lever in very small increments. This process may take several attempts.

- 15. Repeat steps 8 through 14 until the breaker does NOT trip with the 0.090" gauge inserted in the trip coil armature gap and does trip with 0.030" gauge inserted into the trip coil armature gap.
- 16. Perform the latch check switch adjustment per the procedure found in Ch 5 Maintenance, B. Mechanism Area, 4) Mechanism Adjustments, d. Latch Check Switch Adjustment.
- 17. Replace circuit breaker front cover.

d. Latch Check Switch Adjustment

Figure 21 Latch Check Switch Adjustment



- a. Latch Check Switch
- b. Latch Check Operator
- c. Secondary Trip Prop Adjusting Screw

The latch check switch adjustment (Figure 21) described is not required for routine maintenance; however, the latch check switch may need to be adjusted after major overhaul, removal of the mechanism, or tripping system adjustment.

To adjust the latch check switch perform the following steps:

- Remove the main closing spring as described in Ch 5 Maintenance,
   B. Mechanism Area, 3) Closing Spring Removal.
- 2. Rotate the crank arms until the spring charge indicator displays, CLOSING SPRING CHARGED.
- 3. Loosen the two screws which secure the latch check switch and rotate the latch check switch about the pivot screw downward to the lowest position allowed. The latch check switch contacts are now OPEN.









- 4. Insert a 0.045" gauge between the secondary trip prop adjusting screw and latch check operator. Rotate the latch check switch upwards until the contacts are closed. (An audible click of the contacts will be heard.) At the position where the click is heard hold the switch and retighten the two screws which secure the latch check switch. Remove the gauge.
- 5. To confirm that the latch check switch is properly set, slowly depress and release the manual trip operator to verify that the latch check switch OPENS and CLOSES properly. An audible click of the contacts will be heard. The latch check switch contacts will OPEN as the latch check operator is moved by the manual trip operator away from the secondary trip prop adjusting screw. Slowly withdraw the manual trip operator and the latch check switch contacts should close when the latch check operator is between 0.045" to 0.015" away from the secondary trip prop adjusting screw.
- 6. Depress the manual close operator and rotate the crank arm until resistance is felt.
- Depress and hold the manual trip operator inward and rotate the crank arms until the spring charge indicator displays, CLOSING SPRING DISCHARGED.
- 8. Reinstall the circuit breaker main closing spring.

### e. Adjustment of Close Latch Shaft

The close latch shaft (Figure 4, y) passes through the side sheets of the stored energy mechanism frame at the front of and below the cam shaft. The left end of the shaft is shaped to make a latch face and interferes with the close latch arm (Figure 4, x), which is fixed to the cam shaft. The other end of the close latch shaft is on the right side of the mechanism and a small lever attached to it is positioned by a close bar adjusting screw (Figure 4, ad).

To adjust the close latch shaft perform the following procedures:

- 1. Remove the escutcheon.
- Loosen the locking nut from the close bar adjusting screw while holding the position of the close bar adjusting screw with a screw driver.
- 3. Back out the close bar adjusting screw by turning the screw counterclockwise 2 full turns.
- Manually charge the circuit breaker main closing spring with a manual charging handle until the spring charge indicator displays CLOSING SPRING CHARGED.
- 5. Turn the close bar adjusting screw clockwise until the main closing spring discharges, then depress the manual trip operator to OPEN the circuit breaker.
- 6. Turn the close bar adjusting screw 3 to 3½ full turns counterclockwise. Retighten the locking nut holding the screw.
- 7. Repeat *step 5*. Then CLOSE and OPEN the circuit breaker to ensure proper operation.
- 8. Replace the escutcheon.



#### 6) Electrical Operation

After performing any necessary mechanical and lubrication maintenance, operate the circuit breaker electrically several times to ensure that the electrical control system works properly. See Ch 4 Installation, D. Placing the Circuit Breaker Into Service, 5) Electrical Operation Check.

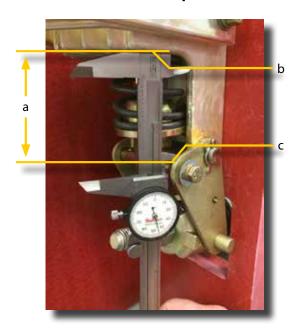
#### C. VACUUM INTERRUPTER AND CONTACT AREA

1) Vacuum Interrupter and Contact Erosion

The contact travel of the vacuum interrupter contacts is measured by subtracting the lengths between the lower contact block and the vacuum interrupter linkage pins in both the open and closed positions.

Using calipers, measure from the bottom of the lower Current Transfer Block to the top of the Operating Pin. Refer to *Figures 22 & 23*. Record the value measured.

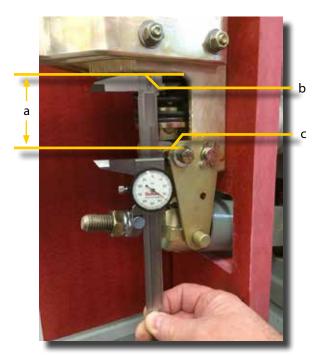
Figure 22 Measurement of Open Position



- a. Open Position Gap
- b. Bottom of Current Transfer Block
- c. Top of Operating Pin

Measure the distance between the bottom of the lower Current Transfer Block and the top of the Operating Pin.

Figure 23 Measurement of Closed Position



- a. Closed Position Gap
- b. Bottom of Current Transfer Block
- c. Top of Operating Pin

Then, subtract the Closed Position from the Open Position. This value is the Contact Wipe. Record and date this value in the Maintenance Log. It is the starting point for monitoring contact wear.









A label is supplied on each vacuum interrupter with the original setting and end-of-life dimension for that particular interrupter installed on each circuit breaker. Repeat the process for all 3 poles.

When the measurement reaches the end-of-life value given on the label, the vacuum interrupter should be replaced. If the field measurement differs from the value on the label by more than 0.01 inches, recheck the measurement and inspect the breaker for evidence of shifting. If no damage can be found and numbers still do not match, consult Powell Service Division for further instruction.

#### 2) Sliding Contact Finger Wear

The 5kV PowlVac-ND® and PowlVac-NDA™ Series 4 circuit breakers use a multi-contact assembly located inside the lower contact block and in direct contact between the moving stem of the vacuum interrupter and the lower contact block. Each lower contact block also uses polymer bushings to support and align the movement of the vacuum interrupter's moving stem. Because the current transfer mechanism is located inside the lower contact block and shielded from the outside atmosphere by the polymer bushings, no scheduled preventative maintenance is required for the sliding contacts.

#### *3) Vacuum Integrity*

Refer to *Ch 4 Installation, D. Placing the Circuit Breaker Into Service* for information on vacuum integrity and testing of vacuum interrupters.

#### 4) Mechanical Adjustment of Vacuum Interrupters

There are no adjustments required for routine maintenance of a vacuum interrupter assembly. There are several factory adjustments which will vary over the operating life of the vacuum interrupter.

## **A CAUTION**

Adjustments of these settings are only necessary when repair requires the removal or replacement of the vacuum interrupter. Do not adjust these settings unnecessarily as damage to the circuit breaker may result.

When it is necessary to remove or replace the vacuum interrupter it should only be done by a qualified technician or a Powell service technician. Contact Powell for further assistance at 1.800.480.7273.

#### **D.** OPTIONAL MAINTENANCE PROCEDURES

#### 1) High Potential Tests

High potential tests are not required for routine maintenance but are recommended after a heavy fault interruption, any major circuit breaker repair that involves the primary current path or when the circuit breaker has been in storage for an extended time, especially in a damp location or other adverse environment. In these cases, both the High Voltage Insulation Integrity and Control Voltage Insulation Integrity tests should be performed. For details of maintenance procedures, see

Ch 4 Installation, D. Placing the Circuit

Breaker Into Service.



# PowlVac-ND® and PowlVac-NDA™ Series 4 Vacuum Circuit Breakers

#### 2) Timing

Perform **CLOSE** and **OPEN** timing tests at the nominal control voltage. The voltage is printed on the circuit breaker nameplate.

To measure **CLOSE** timing, operate the test source to the **CLOSE** position. When the circuit breaker closes, record the closing time. The closing time from energizing the closing coil to vacuum interrupter contact touch should not exceed the values in *Table C, Timing*.

Table C Timing				
Cycles	Closing Time (ms)	Tripping Time (ms)		
3	<80	<35		
5	<80	<55		

To measure **OPEN** timing, operate the test source to the **OPEN** position. When the circuit breaker opens, record the closing time. Operate the test source to the **OPEN** position to open the circuit breaker and record the opening time. The opening time from energizing the shunt trip coil to vacuum interrupter contact part should not exceed the values listed in *Table C, Timing*.

#### 3) Primary Resistance Check

The primary resistance check is not required for routine maintenance but it is recommended after any major maintenance that requires disassembly of any part of the primary current path.

To check the primary resistance, pass a minimum of 100A DC through the circuit breaker pole, with the circuit breaker closed. Measure the voltage drop across the primary contacts and calculate the resistance. The resistance should not exceed the values provided in this

instruction bulletin for the specific type and rating of the circuit breaker being measured.

When making this test, be sure the test current passes through both main horizontal primary disconnecting devices of each pair or resistance measurement will be affected. This may be done by connecting the current source leads to two blocks of full round edge copper 3/4" thick by 3 or 4 inches wide by 4 inches long and pressing these blocks into the upper and lower primary disconnecting devices of the circuit breaker. The blocks should be silver or tin-plated to simulate the primary disconnecting devices in the circuit breaker compartment. The voltage drop measurement may be made between these two blocks.

The micro-ohm values of resistance must not exceed the limits in *Table D, Primary Resistance*.

Table D Primary Resistance					
Breaker Type	Rated (kV)	Continuous Current (Amperes)	Resistance (Micro-ohms)		
05PV36SNDX-4	5	1200	100		
05PV36SNDX-4	5	2000	80		
05PV50SNDX-4	5	1200	100		
05PV50SNDX-4	5	2000	80		
05PV36SNDM-4	5	1200	100		
05PV36SNDM-4	5	2000	80		
05PV50SNDM-4	5	1200	100		
05PV50SNDM-4	5	2000	80		
05PV36NDAX-4	5	1200	100		
05PV36NDAX-4	5	2000	80		
05PV50NDAX-4	5	1200	100		
05PV50NDAX-4	5	2000	80		
05PV36NDAM-4	5	1200	100		
05PV36NDAM-4	5	2000	80		
05PV50NDAM-4	5	1200	100		
05PV50NDAM-4	5	2000	80		









### Ch 6 Recommended Renewal Parts and Replacement Procedures

#### A. ORDERING INSTRUCTIONS

- 1. To order Renewal Parts from Powell, visit the website at *powellind.com* or call 1.800.480.7273.
- 2. Always specify the 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 parts 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 or photo.

#### **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. *Tables E, F, and G* list the recommended spare parts to be carried in stock by the user. The recommended quantity is not specified. This must be determined by the user based on the application. 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 these units. If these circuit breakers are installed in a location where they are not maintained by a qualified technician, a spare circuit breaker should be on site ready for circuit breaker replacement. The malfunctioning unit can then be returned to the factory for reconditioning.

#### C. REPLACEMENT PROCEDURES

This section includes instructions for replacing the parts recommended as renewal parts. Before attempting any maintenance repair work, take note of the safety practices outlined in *Ch 2 Safety* of this instruction bulletin.

### **A CAUTION**

Ensure that the control circuits are deenergized and the circuit breaker is deenergized, disconnected by means of a visible break, and securely grounded. Do NOT start to work on a closed circuit breaker or a circuit breaker with the main closing spring charged. When any maintenance procedure requires the opening or closing of the circuit breaker or the charging of any of the stored energy mechanism springs, exercise extreme caution to ensure that all personnel, tools, and other miscellaneous objects are kept clear of the moving parts of the charged springs.

# PowlVac-ND® and PowlVac-NDA™ Series 4 Vacuum Circuit Breakers

1) Vacuum Interrupter Assembly

## NOTICE

The vacuum interrupter should only be replaced by a qualified person or a Powell Service technician. Contact Powell for further assistance at 1.800.480.7273.

2) Closing Coil Assembly

Refer to service manual 01.4SM.1300 Closing Coil Assembly for replacement and installation procedures.

3) Primary Shunt Trip Coil Assembly

Refer to service manual 01.4SM.1600 Primary Shunt Trip Coil Assembly for replacement and installation procedures.

4) Secondary Shunt Trip Coil Assembly

Refer to service manual 01.4SM.1700 Secondary Shunt Trip Coil Assembly for replacement and installation procedures.

5) Undervoltage Device Assembly

Refer to service manual 01.45M.1801 Undervoltage Device for PowlVac-ND® for replacement and installation procedures.

6) Charging Motor Assembly

Refer to service manual 01.4SM.1200 Charging Motor Assembly for replacement and installation procedures.

7) Anti-Pump Relay Assembly

Refer to service manual 01.4SM.1000 Anti-Pump Relay Assembly for replacement and installation procedures.

#### 8) Latch Check Switch

Refer to service manual 01.4SM.1400 Trip Adjustment and Latch Check Switch for replacement and installation procedures.

9) Motor Cutoff Switch Assembly

Refer to service manual 01.4SM.1500 Motor Cutoff Switch Assembly for replacement and installation procedures.

10) Auxiliary Switch

Refer to service manual 01.4SM.1100 Auxiliary Switch Assembly for replacement and installation procedures.









Table E Primary Current Path						
Breaker Type	Rated (kV)	Rated Continuous Current (Amps)	Vacuum Interrupter Assembly	Primary Disconnecting Device Assembly	Operating Pushrod Assembly	
05PV36SNDX-4	4.76	1200	77014G01	77018G01	77017G01	
05PV36SNDX-4	4.76	2000	77014G01	77018G01	77017G01	
05PV36SNDM-4	4.76	1200	77014G01	77018G01	77017G01	
05PV36SNDM-4	4.76	2000	77014G01	77018G01	77017G01	
05PV50SNDX-4	4.76	1200	77014G03	77018G01	77017G02	
05PV50SNDX-4	4.76	2000	77014G03	77018G01	77017G02	
05PV50SNDM-4	4.76	1200	77014G03	77018G01	77017G02	
05PV50SNDM-4	4.76	2000	77014G03	77018G01	77017G02	
05PV36NDAX-4	4.76	1200	77014G01	77018G01	77017G01	
05PV36NDAX-4	4.76	2000	77014G01	77018G01	77017G01	
05PV36NDAM-4	4.76	1200	77014G01	77018G01	77017G01	
05PV36NDAM-4	4.76	2000	77014G01	77018G01	77017G01	
05PV50NDAX-4	4.76	1200	77014G03	77018G01	77017G02	
05PV50NDAX-4	4.76	2000	77014G03	77018G01	77017G02	
05PV50NDAM-4	4.76	1200	77014G03	77018G01	77017G02	
05PV50NDAM-4	4.76	2000	77014G03	77018G01	77017G02	

**Primary Current Path** Figure 24

b



- a. Primary Disconnecting Device Assembly
- b. Vacuum Interrupter Assembly
- **Operating Pushrod Assembly**



# PowlVac-ND® and PowlVac-NDA™ Series 4 Vacuum Circuit Breakers

Table F Control Devices							
Control Voltage	Closing Coil Assembly	Primary Shunt Trip Coil Assembly (3 cycle) (2)	Primary Shunt Trip Coil Assembly (5 cycle)	Secondary Shunt Trip Coil Assembly (1, 3)	Undervoltage Device Assembly	Charging Motor Assembly	Anti-Pump Relay Assembly (5)
48VDC	77026G01	77027G01	50041G01	50042G01	50028G21 (4)	77318G01	RR2BA-US-DC-48V
125VDC	77026G03	77027G02	50041G02	50042G03	50028G20 (4)	77318G02	RR2BA-US-DC 110V
250VDC	77026G04	77027G03	50041G03	50042G04	(4)	77318G03	RR2BA-US-DC 110V
120VAC	77026G01	77027G01	50041G05	50042G01	n/a	77318G02	RR2BA-US-AC 120V
240VAC	77026G02	77027G06	50041G06	50042G02	n/a	77318G03	RR2BA-US-AC 240V
Capacitor Trip (6)	n/a	50027G04	50041G04	50042G05	n/a	n/a	n/a

#### **Notes:**

- 1) One required per circuit breaker if the circuit breaker was originally equipped with this item. All circuit breakers have a closing coil, primary shunt trip coil, charging motor, and an anti-pump relay assembly. Secondary shunt trip coils and undervoltage device assemblies are optional (see notes 2-7).
- 2) Primary shunt trip coil is available as a 3 cycle and 5 cycle control device. A circuit breaker with an original 5 cycle trip coil may not be replaced with a 3 cycle trip coil as damage to the circuit breaker may occur. A circuit breaker with an original 3 cycle trip coil may be replaced with a 5 cycle trip coil.
- 3) Secondary shunt trip coil cannot be furnished with an undervoltage device assembly.
- 4) Where furnished, cannot be present with secondary shunt trip coil assembly.
- 5) For 250VDC applications, a dropping resistor 50747G02 is required in series with the anti-pump relay assembly.
- 6) For use with capacitor trip units with 240VAC input. Consult factory for other circuit breaker ratings.
- 7) All control devices are available with push-on terminals. Consult factory for control devices with screw terminals.

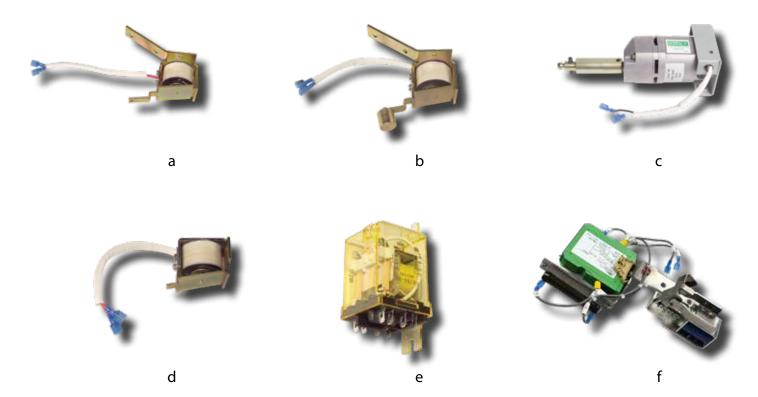








Figure 25 Control Devices



- a. Primary Shunt Trip Coil (3 cycle)
- b. Primary Shunt Trip Coil (5 cycle)
- c. Charging Motor Assembly
- d. Closing Coil Assembly
- e. Anti-Pump Relay
- f. Undervoltage Device Assembly



### PowlVac-ND® and PowlVac-NDA™ Series 4 **Vacuum Circuit Breakers**

Table G Miscellaneous Parts					
Description	Catalog Number	Illustration			
Auxiliary Switch Push-on Terminals	102112PB				
Ground Connection	69433G01				
Latch Check Switch	BA-2RV2-A2				
Motor Cutoff Switch Assembly	77034G01				
PowlVac® Hardware Kit	60500G24				
PowlVac® Lubrication	Powlube-104	POWELL  MATERIAL TO  MATERIAL T			
Operating Pushrod Assembly					
5kV 36kA	77017G01	W Dee			
5kV 50kA	77017G02				











## 01.4IB.77020 PowlVac-ND® and PowlVac-NDA™ Series 4 **Vacuum Circuit Breakers**

5kV 1200A & 2000A 36kA & 50kA

May 2018