Instruction Manual for Oil-Free PRC® Bushings with Polymer Insulator

1. Scope

This instruction contains general procedures to be followed during receiving, installation, storage, and maintenance of all PCORE® PRC® bushings that utilize a polymer insulator. This instruction does not cover all contingencies that may arise during installation, operation, or maintenance of such equipment. If you require additional information regarding a particular installation and the operation or maintenance of your bushing, contact PCORE. PCORE does not assume any liability or responsibility for any damage or failure that would result from improper transportation, application, installation, storage, or maintenance.

2. Safety

These tasks may cause safety hazards if they are not performed properly. Those who are responsible for or involved in the installation, maintenance, storage, and operation of the bushings must read this instruction and understand the details before they perform the tasks. Required procedures and instructions must be followed when installing bushings on apparatus or building (hereafter, any equipment or buildings on which bushings are to be installed will be called apparatus).

All applicable safety procedures such as OSHA requirements, regional and local safety requirements, safe working practices and good judgment must also be used by personnel when installing, operating, and maintaining such equipment.

Some of the hazards associated with these tasks are:

Lethal electric shock

Fire or burning due to high current

Lifting hazards

Heavy equipment

High pressure

Hot oil

Hazards will be identified by the three following categories:

DANGER — *Immediate hazard, which **WILL** result in **SEVERE** personal injury, death, or property damage.*

WARNING — *Hazard or unsafe practice, which **MAY** result in **SEVERE** personal injury, death, or property damage.*

CAUTION — *Hazard or unsafe practice, which **MAY** result in **MINOR** personal injury or property damage.*

3. Bushing Components

3.1 Housings

The top insulating housings are made of a polymer composite. The housing consists of an electrical grade fiberglass tube that has fittings and silicone rubber directly bonded to it.

3.2 Conductors

Lower current bushings have aluminum conductors and high current bushings have copper conductors.

3.3 Insulation Materials

Standard PRC bushings use electrical grade crepe paper impregnated with electrical grade resin as its primary insulation. Between the housing and the primary insulation, a dielectric gel forms an interstitial insulation.

WARNING — *The PRC bushings with polymer insulators do not contain any oil. Therefore, it will never be necessary to open up any of the fill plugs, as this could introduce contaminants into the bushing's interstitial insulation. This act could cause damage and eventual failure of the bushing.*

3.4 Flanges and Flange Adapters

Flanges and flange adapters are made of aluminum. For replacing older bushings or other manufacturers' bushings, PCORE offers custom-made flange adapters.

3.5 Terminals

Terminals are copper or brass. Some are silver or tin plated.

4. Cable Connections

4.1 Bottom Connections

PCORE PRC bushings have one of the following bottom terminals: Flat spade or threaded stud. The bushings with a flat spade can be directly connected to the apparatus. The bushings with a threaded stud MAY need adapters to connect to the apparatus.

4.2 Draw Lead Connections

Some bushings are designed with a hollow conductor through which a flexible cable or a rod can be pulled. The cable is a part of the apparatus on which the bushing is mounted and is not supplied with the bushing. Most draw-lead terminals have a flat spade for brazing, crimp type, or tubular brazing terminals are available.

4.3 Transformer and Oil Circuit Breaker Interchangeability (TBI)

The 800-ampere draw-lead bushings in the 115 kV and 138 kV class can be bottom connected for 1200-ampere transformer rating and can also be 1600 ampere bottom connected for oil circuit breaker application.

PCORE PRC bushings can provide maximum interchangeability between transformer and oil circuit breaker applications with the same basic bushing by just changing some hardware. The current rating for transformer application is based on an oil temperature rise of 65K (as governed in IEEE standards) while that for the oil circuit breaker application is on an oil temperature rise of 50K (as governed in IEEE standards).

5. Crates

PRC bushings are shipped in crates with top covers held in place with reusable fasteners. The top covers of export bushings are nailed.

PRC bushings are shipped with opaque plastic bags covering the bottom resin section of the bushing. These bags protect the resin section from ultra-violet rays.

6. Receiving and Incoming Inspections

You should perform a visual inspection on the crate and the bushing before unloading. When unloading crates, you must take extreme care not to damage the crates or the bushings. Do not drop the bushings. The bushings should be unpacked in a flat, dry area.

The clips (on crates with reusable clips) can be removed using a claw hammer. Remove any nailed covers carefully to avoid damage.

Some crates contain separate boxes containing special terminal adapters, bottom shields, or other special parts. These special parts should also be checked for damage from shipment.

Examine the bottom resin for cracks or chips. Check all parts for physical damage. Any special parts packaged separately should also be checked for damage.
If shipping damage is evident, you must file a claim with the transportation carrier and notify PCORE of the claim immediately.

7. Storage

The PRC bushing can be stored either horizontally or vertically in a proper stand which cannot be tipped over. The preferred location is indoors, however bushings may be stored outdoors with the bottom end covered with an opaque plastic bag. The crates are not made for extended outdoor storage; inspect the crates periodically for weather damage while ensuring the bottom resin surface remains covered in an opaque plastic bag.

WARNING

While in storage it is pertinent to prevent the resin bottom of the bushing from being in continual contact with UV light. Continuous contact with UV light can damage the resin of the bushing and cause failure of the bushing.

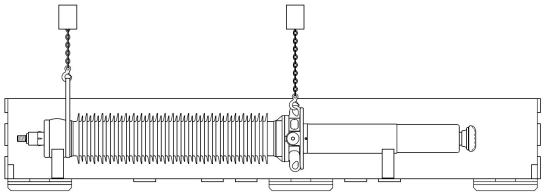
For long term outside storage, moisture or water may gather inside the protective plastic bag that covers the upper and lower end. Suitable protection, such as water-repellent grease should be provided for top and bottom terminals, and mounting hardware to protect the contact area from corrosion.

8. Handling and Installation

8.1 Removing Bushings from Crates

These PCORE PRC bushings are provided with lifting eyes in the flange. Because of the size and weight of the bushings, they may require special handling. Before lifting a bushing, remove any mounting flange bolts holding the bushing in the crate and any other method of support which may be used to secure the bushing.

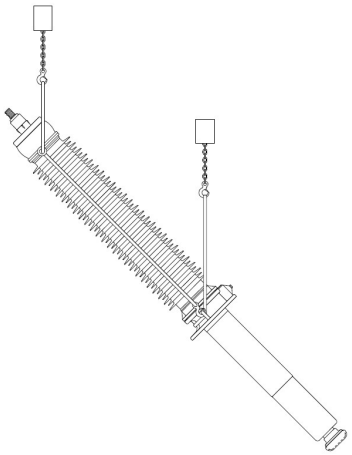
The main lifting tackle should always be attached to the flange lifting eyes. A second crane hook must be attached to a double sling with a choker rope tied around the bottom of the top metal tank.

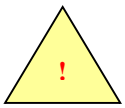


8.2 Moving Bushing for Installation

Tie two choker ropes around the top tank. Attach two slings to one crane hook. Pass the other end of the sling through the eyes of each choker rope. Attach a shackle to each of these ends. Connect the shackles to the lifting eyes of the mounting flange 180 degrees apart.

Pass a sling through eyes of mounting flange and attach both ends to the second crane hook. Attach a sling to the second crane hook. Attach the end of choke rope to the hook.





WARNING

*The weather sheds of the polymer insulator are **not** designed for lifting. Using the weather sheds as a support for lifting could cause the bushing to drop and or cause damage to the polymer insulator.*

CAUTION

When lifting the bushing care should be taken to avoid contact of lifting chains or other abrasive lifting straps/cables with the polymer as these materials could potentially damage the weather sheds.

8.3 Cleaning

The bushing upper housing is made of a composite silicone rubber material. This material is considered “self-cleaning” and should not need cleaning when received. Due to the properties of the silicone the outer insulator surfaces are hydrophobic which helps minimize leakage current caused by contamination. In some applications where the insulator is exposed to extreme contamination conditions such as but not limited to salt spray or cement dust, the insulator may require cleaning periodically. It is recommended to clean the surface after 50% of the surface’s hydrophobicity is lost. This condition can be verified by misting water from about a foot away from the surface over a small area of the silicone. The water should bead up versus forming a film on the surface.

When cleaning of the silicone insulator is desired or required it is recommended to utilize a silicone fluid emulsion, such as POWERSIL Shine made by Wacker Chemie, with a dry lint free cloth. It is also acceptable to clean the silicone sparingly with alcohol or acetone with a lint free cloth followed by completely rinsing the surface with water. If pressure washing is to be performed, to avoid damage, the pressure at the nozzle shall not be higher than 500 psi, the distance between the nozzle and the silicone shall be no closer than 10 feet, and the water jet shall not be positioned on a point any longer than 10 seconds.

WARNING

After cleaning the insulator, the insulating performance is temporarily reduced. Wait at least 24 hours before re-energizing.

CAUTION

Use all cleaning products as prescribed per their SDS (Safety Data Sheet).

Prior to instillation for cleaning, bushings should be kept vertically in a secure stand and you must remove all dust, grease, oil, or particles from the inboard end (oil end) with a clean dry lint free cloth to prevent contamination of transformer oil. Before mounting bushings to the apparatus cover, inspect and clean the mounting surfaces of both the bushing and apparatus.

Check the inside wall of the draw-lead tube especially when the bushing has been stored outdoors a long time. If it is dirty, remove all the dirt, dust, and other foreign materials from the tube surface.

8.4 Electrical Tests

PCORE recommends that power factor and capacitance measurements be performed on all bushings before installation. The measured values should be compared with those on the nameplate. The nameplate values are of special importance in asking PCORE questions about bushings. The bushing must be kept vertically in a secure stand for the electrical tests.

See 9.2 for further recommended practices, test requirements, and troubleshooting.

These measurements should agree with the nameplate values within equipment tolerances and should be kept as reference readings. When power factor and capacitance readings disagree with nameplate data beyond reasonable tolerances, you should contact the factory at Le Roy.

Never test the bushing while in the shipping crate.

When possible, place the bushing in a grounded test stand. It is important to isolate the flange from the grounded stand using a good insulating material. ***Wood can contain significant moisture and should never be used.***

CAUTION

The readings may be taken with the bushing installed in the equipment provided the top terminal connections are not made or the terminal is isolated from the main bus via a PCORE Test terminal.

After the testing has been completed, reassemble the tap cover after coating the “o-ring” lightly with silicone grease and tighten the cap.

Do not operate the bushing without the test tap or voltage tap cover in place.

WARNING

DANGER

Prior to installing the bushing, it must be verified that the apparatus that will have the bushing installed is properly de-energized and grounded.

8.5 Mounting Bushings

8.5.1 Vertical and Horizontal Mounting

Lift the bushings in the same way as removing bushings from the crates. If a flange adapter is required, install it before moving the bushing to the mounting hole. Put the gaskets and/or o-rings on the apparatus mounting surface per the apparatus instruction. Move the bushing to the mounting hole of apparatus. Tighten the bolts to the torque specified from the apparatus manufacturer.

8.5.2 Draw-Lead Connection

Bushings designed for draw-lead applications have the draw lead terminal, nut, and pin in place. Before installation, you must remove the top terminal, the draw lead nut, the retaining pin, and the draw lead terminal. Braze the apparatus cable to the draw lead terminal (alternatively crimp type terminals are available). Pass a wire or pull cord through the bushing center conductor from the top and attach it to the hole in the top end of the draw lead terminal on the flexible cable. While lowering the bushing into the opening in the cover, simultaneously pull the cable up through the center conductor. Secure the draw lead terminal into the top of the bushing by replacing the retaining pin through the conductor and then replace the draw lead nut. A light coating of o-ring lubricant should be applied to the o-ring of the top terminal before replacing. Refer to the section Bolting and Terminal Torque Settings for terminal tightness.

8.5.3 Torque Specifications for Bolts

Before mounting bushings to the apparatus cover, inspect and clean the mounting surfaces of both the bushing and apparatus. Install the gasket or o-ring supplied by the apparatus manufacturer. Secure the bushing on the apparatus cover by tightening all the bolts uniformly in several steps. Do not attempt to pull the bolts down to the final setting on the first tightening. It is good practice to allow time between the several tightening steps for the gasket to set. Care in tightening avoids possible damage or distortion of the mounting flange. Normally, the torque values as listed will provide adequate compression for sealing.

Use the torque recommendations and mounting specification of the apparatus manufacturer. Reduce torque if gasketed per manufacturing recommendations for material being used. Adjust torque for other metals for bolts in flange. Values below are for SAE Grade 1 or 2.

BUSHING FLANGE	
Bolt Diameter (inch)	**Torque ft-lb (N-m)**
¾	105 (142)
1	200 (271)
1 1/8	250 (339)

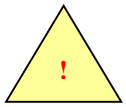
DRAW LEADS		
Current (ampere)	**Thread Size inch**	**Torque ft-lb (N-m)**
400	¾	20 (27)
800	1 1/4	40 (54)

REMOVABLE TOP TERMINALS	
kV Class	**Torque ft-lb (N-m)**
≤72.5	50 (68)
>72.5	80 (108)

8.5.7 Bottom Terminals
If a bottom terminal and/or shield is to be installed, use 40 ft-lb (54 N-m) for the 1/2-13 or M12x1.75 SST. bolts and 20ft-lb (27 N-m) torque for the 3/8-16 SST. bolts. Pass the cable through the hole in the shield and mount the bottom terminal. Then push the shield to the bushing and mount the shield on the bushing.

8.5.8 Top Terminals
After power factor and capacitance tests are completed for the apparatus, connect the top terminal for energization.

8.5.9 Terminal Connectors
All external terminal connectors that are used to connect to the bushings shall follow the requirements of IEEE C57.19.00 and NEMA CC1. The connector utilized under rated current should not lead to a top terminal temperature that exceeds 30K rise over ambient temperature or a maximum temperature of 70°C. PCORE offers a line of Test Terminals that meet the requirements of these standards for bushing external connections.



WARNING

Terminal connectors that fail to meet the requirements of IEEE and NEMA standards could lead to the degradation of seals and insulation which could lead to the failure of the bushing.

9. Maintenance
Little maintenance is required other than periodically performing visual inspections and performing dielectric field measurements.

9.1 Top Terminal Inspection
The top terminal and the connectors attached to it must remain properly fastened to the bushing. If a connector at the top of the bushing does not remain properly tightened a hot spot can form at the top of the bushing which could lead to seal and insulation degradation. To verify that connectors at the top of the bushing remain properly installed it is recommended to perform infrared temperature scans to look for abnormal hot spots.

9.2 Dielectric Field Measurement
The methods of measuring power factor and capacitance are in the user manual of your power factor measuring device or consult IEEE Standard C57.152 *IEEE Guide for Diagnostic Field Testing of Fluid-Filled Power Transformers, Regulators, and Reactors*. Only C_1 power factor and capacitance have meanings for the 15 kV through 72.5 kV class bushings. PCORE recommends against measuring C_2 power factor and capacitance of these voltage class bushings for any purpose. For all kV classes higher than 72.5kV it is recommended to test both the C_1 and C_2 power factors.

All bushings that are between 15 kV and 72.5kV class are outfitted with a test tap. For C_1 power factor tests it is recommended that power factor tests be performed at 10kV, as this matches the voltage at which the nameplate value is obtained from. If bushings with a test tap are to be C_2 power factor test, although not recommended, the test voltage used should be no higher than 0.5kV.

All bushings with kV classes that exceed 72.5kV are outfitted with a voltage tap. For C_1 power factor tests it is recommended that power factor tests to be performed at 10kV and 2kV for C_2 power factor, as this matches the voltage at which the nameplate value is obtained from.

We endorse and recommend the measurement of power factor and capacitance at the time of installation and repeating the measurement regularly. These values should be used as a base to compare the TRENDS of future measurements. Field measurements of power factor and capacitance may differ from measurements made under the controlled conditions in the factory. Contact the factory if you encounter any of the following:

A. Measurement of power factor increases to 1.5 times the original installation value.
B. Measurement of capacitance increases by 10 percent over the original installation value.

9.2.1 Power Factor Temperature Correction
All PRC bushings due to their constructed materials will have a varying power factor with temperature. The power factor results as the nameplate value for PRC bushing is either tested at or corrected to that of a temperature of 20°C. The field test results should be corrected to 20°C with the best estimation of the bushings temperature. The proceeding formula and correction factor table can be utilized to determine the power factor at 20°C. For further guidance and correction factors please reference B-330800-PRCE. For most accurate results it is recommended to test at temperatures greater than 15°C.

$$PF_{Corrected} = (PF_{Tested})(C_F)$$

Temperature (°C)	Correction Factor [C_F]
0	0.776
5	0.832
10	0.888
15	0.944
20	1.000
25	1.056
30	1.112
35	1.168
40	1.224

9.2.2 Power Factor Testing Issues
Depending on the test setup and other circumstances power factor discrepancies observed in the field may indicate some testing issues that are occurring. The following list includes a brief list of common issue that have been observed, a more complete list can be found in B-330800-BSHA.

- Verify the test set is in proper working order.
- Verify no objects are in contact with the bushing insulator.
- Verify all grounding connections are properly made.
- Verify the tap area is dry and clean.
- Verify if the insulator requires cleaning (see 8.3).
- Only remove the tap cover of the bushing directly under test.

10. Re-shipping or Returning Bushings

To ship the bushing to another site, you may re-use the original crate. **Inspect the crate for damage and repair before using.** Ensure the bottom resin section of the bushing is protected from UV light, the opaque bag that was used in the initial packaging can be reused for this purpose.

It is recommended that bushings be returned to the factory for all significant repairs, if needed. Inquiries concerning repairs should be addressed to the factory at Le Roy. You MUST obtain a Return Material Authorization (RMA) number before shipping bushings or bushing attachments to PCORE. The handling of all requests will be expedited if the factory is furnished the
catalog number and the serial number which are on the nameplate. The catalog number identifies the bushing rating. The first two digits of the serial number are the last two digits of the manufacturing year.

WARNING

Do not attempt field repairs. Bushings are assembled using heavy clamping pressures. Attempting to disassemble the bushing may cause injury or damage.