

Bushings

44-665D
Instruction Leaflet

April 1, 1993
Supersedes IL 44-665C
Dated January 2, 1990

Instructions for Installation, Maintenance and Storage of Type "O Plus C" Bushings 25 kV through 72.5 kV.

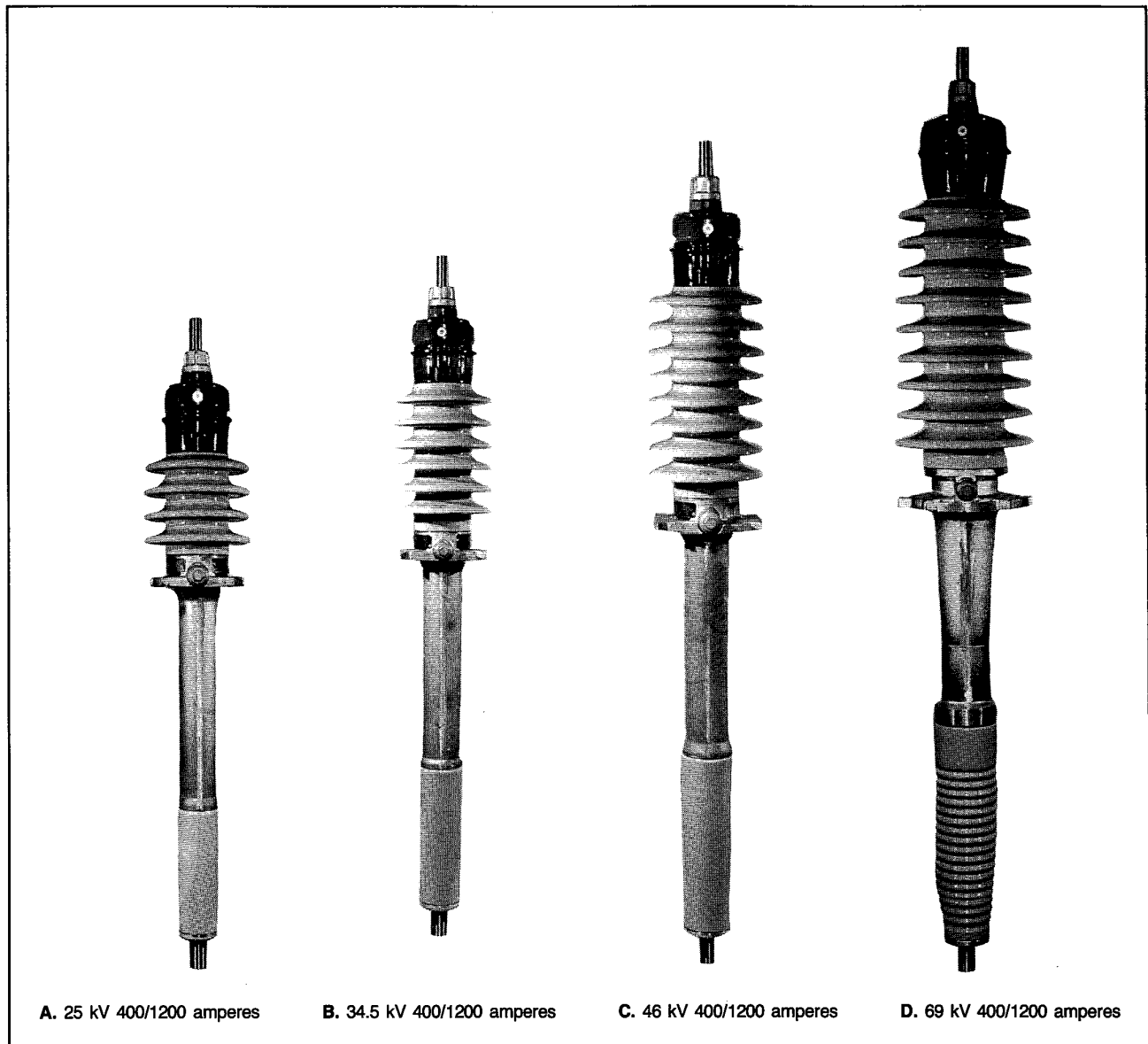


Figure 1: Typical Type "O Plus C" Bushings

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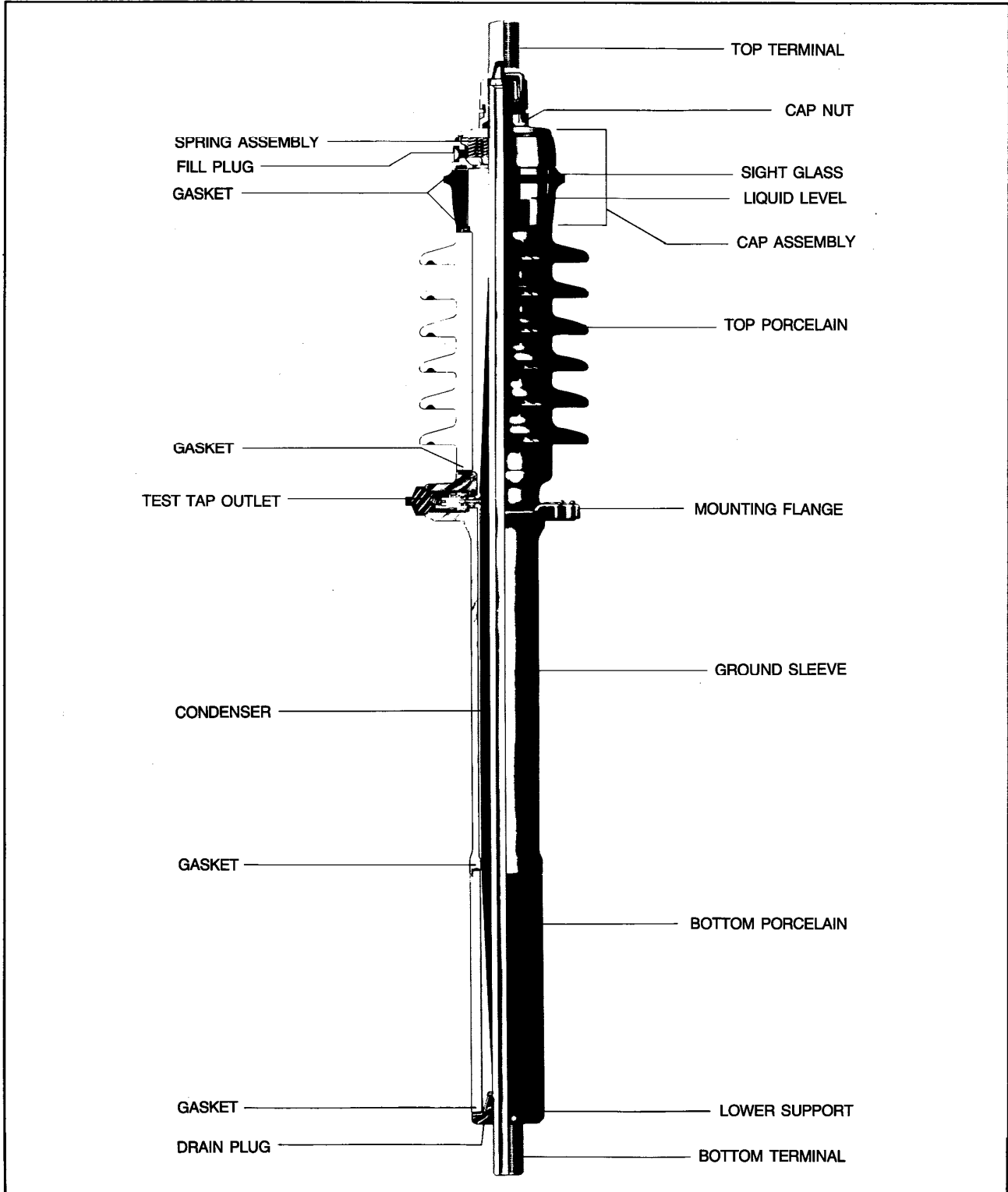


Figure 2: Cutaway view of an "O Plus C" bushing.

SCOPE

This leaflet contains general procedures to be followed from the time the bushings are received until they are put into operation. All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If you require additional information regarding this particular installation and the operation or maintenance of your equipment contact the local ABB Power T&D Company Inc. representative.

GENERAL INFORMATION

Type "O Plus C" condenser bushings are designed for transformer and oil filled circuit breaker applications. Type "O Plus C" condenser bushings meet all applicable dimensional requirements of the IEEE Standard C57.19.01-1991 and meet or exceed all applicable electrical and mechanical requirements of the IEEE Standard C57.19.00-1991. Type "O Plus C" condenser bushings are also manufactured to meet the E.E.M.A.C. Standard. The type "O Plus C" condenser bushings are manufactured exclusively at the Components and Division Plant in Alamo, Tennessee.

Type "O Plus C" condenser bushings (see Figures 1 and 2) consist of an oil-impregnated, multi-layered, paper condenser wound on a central tube. The condenser is housed in a sealed cavity formed by the upper and lower porcelain insulators, the high strength one-piece flange, and the glass expansion bowl. The assembly is sealed and clamped by a spring loaded center clamping assembly. This cavity along with the condenser is evacuated and then filled with highly processed insulating oil for a very low moisture content and low bushing power-factor. This low moisture content and low power factor are maintained throughout the life of the bushing by permanently sealing the bushing cavity. Once the bushing cavity is sealed during manufacturing, the seal is never broken. A nitrogen gas cushion above the oil allows thermal expansion of the oil in the sealed cavity.

SAFETY INFORMATION

Keep this Instruction Leaflet available to those responsible for the installation, maintenance, and operation of the Bushing.

The installation, operation and maintenance of a Bushing presents numerous potential unsafe conditions, including, but not limited to, the following:

- High pressures
- Lethal voltages
- Moving machinery
- Heavy components

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow instructions could result in severe personal injury, death, and/or product or property damage.

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

Safety, as defined in this instruction book, involves two conditions:

1. Personal injury or death.
2. Product or property damage (includes damage to the Bushing or other property, and reduced Bushing life.)

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The safety notations are headed by one of three hazard intensity levels which are defined as follows:

1. **DANGER** — immediate hazard which will result in severe personal injury, death, or property damage.
2. **WARNING** — hazard or unsafe practice which could result in severe personal injury, death, or property damage.
3. **CAUTION** — hazard or unsafe practice which could result in minor personal injury, or property damage.

SHIPPING METHOD

Condenser bushings are generally shipped from the plant in Alamo with their upper end elevated above the lower end or in an upright position. We recommend that these bushings be shipped or stored in their own crates or shipped at a seven degree or higher angle (upper end being above the lower end) to prevent any entrapment of gas in the insulation and insure its integrity.

If it is not possible to ship the bushings at an angle or in the upright position, then bushings up to 72.5 kV rating can be shipped to the end user in a horizontal position if the following guidelines are observed.

CAUTION

FAILURE TO FOLLOW THESE GUIDELINES MAY RESULT IN DAMAGE TO THE BUSHING AND CAUSE AN ELECTRICAL FAILURE. FAILURE TO FOLLOW THESE GUIDELINES WILL ALSO CANCEL THE WARRANTY ON THE BUSHING.

1. The bushings can be shipped in a horizontal position to the ultimate destination if the maximum period in transit does not exceed 15 days.
2. The bushings can then be stored in a horizontal position for a maximum period of 15 days.
3. Bushings that have been in a horizontal position for a total period of 30 days or less must be placed in a vertical position for a minimum of 48 hours prior to the application of voltage. This applies to any time period 30 days or less. After the bushing is upright gently rock it to release any nitrogen gas that may be trapped in the insulation.
4. If the bushings are in transit or are stored in a horizontal position exceeding the time in these guidelines, contact Customer Service, ABB Power T&D Company Inc., Components Division, Alamo, TN 38001, telephone (800) 955-8399. Reimpregnation of the condenser at the factory will be required if the specified time periods are exceeded.
5. Bushings should be shipped in their own crates. Generally, two supports are necessary for shipping bushings. One support under the flange and the other under the upper porcelain.

FOR SPECIFIC RECOMMENDATIONS PLEASE CONTACT ABB POWER T&D COMPANY INC.

UNPACKING

As soon as a bushing is received, open the shipping crate or box carefully, and examine the bushing for any damage incurred during shipment. If damage or rough handling is evident, file a claim with the transportation company, and notify your ABB Power T&D Company Inc. representative immediately.

Note the oil level as explained under the heading "Liquid Level Indication" and examine the surface of the porcelain and sight glass for small breaks or cracks which might cause leakage later, but which will not immediately affect the oil level indication.

Although surface oil is removed carefully from Type "O Plus C" bushings after electrical tests, occasionally bushings show evidence of an oil film when received. While this is a cause for concern, the following information should be considered.

1. Type "O Plus C" bushings are pressure tested with oil at 22 psig during manufacturing.
2. The presence of an oil film on the surfaces or joint of bushings can be residual oil remaining after the immersion of the bushings for electrical tests.
3. To check for hidden damage to gasket seals or porcelains which might permit leakage, wipe all bushing surfaces and joints clean and dry and observe for leaks during a 48 hour period.
4. Check for correct oil level — an interface of gas and oil should be visible in the sight glass.

HANDLING

The bushing can be lifted from the crate by the use of a rope sling placed under the top shed of the upper porcelain.

STORING

A type "O Plus C" bushing can be stored outdoors in the shipping crate for short periods. For long term storage, the bushing should be in a vertical position and stored in a clean dry place.

For long term storage, suitable protection should be provided for the terminal and mounting hardware. The gasket surface on the underside of the mounting flange should be heavily greased to protect it from rust and corrosion.

INSTALLATION

Prior to installation, wipe the bushing clean of all dust, grease, oil, or particles of packing materials using a clean dry cloth. Clean the inside of the tube (if open at the oil end) with a suitable cleaner or an alcohol soaked swab to remove any contaminants that may have entered the tube during shipping or storage. We recommend that the capacitance and power factor of the bushing be measured in accordance with the "BUSHING TEST TAP" section of this booklet prior to energizing. After uprighting the bushing, check to insure the internal bushing oil is visible in the sight glass and check for indications of oil leakage from the bushing. Always allow the bushing to equalize to the temperature of the apparatus on which it is being installed prior to energization.

MOUNTING

A bushing with a cylindrical oil level sight glass may be mounted at any angle up to 60 degrees from the vertical. Refer to the outline drawing for specific information. All other applications should be referred to the factory.

PAINTING

The metal parts at the top end are painted for protection against the weather. Care should be used to prevent scratching these painted surfaces. If the metal becomes exposed, the area should be wiped with a commercial safety solvent and then wiped dry. The cleaned area should then be coated with a suitable outdoor gray enamel paint.

BOLTING

Tighten the mounting bolts a fraction of a turn at a time, working progressively in one direction around the bolt circle until all bolts are uniformly tight. Tighten sufficiently to seal the bushing to the apparatus. Normally, the torque values listed below will provide adequate gasket compression for sealing.

SIZE OF BOLT Inch-Thread	TORQUE ft-lb (N-m)
1/2 - 13	25 (34)
5/8 - 11	30 (41)

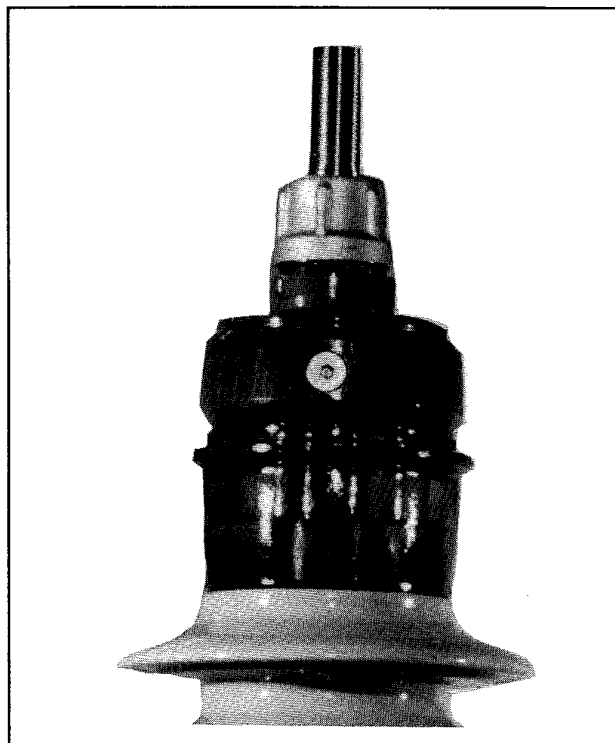


Figure 3: Typical top end of 25 kV - 72.5 kV Type "O Plus C" bushings. Liquid Level is indicated in sight glass by apparent change in conductor size.

CAUTION

BEFORE APPLYING VACUUM TO A TRANSFORMER, BE CERTAIN THERE IS SUFFICIENT SLACK IN THE EXTERNAL LINE CONNECTIONS TO THE BUSHING TO ALLOW FOR BUSHING MOVEMENT CAUSED BY FLEXING OF THE TRANSFORMER COVER AND/OR WALLS. FAILURE TO RELIEVE THIS STRESS AT THE BUSHING CONNECTION MAY RESULT IN DAMAGE TO THE BUSHING SEALS AND LOSS OF OIL. LOSS OF OIL WILL CAUSE AN ELECTRICAL FAILURE.

LIQUID LEVEL INDICATION

The oil level in the bushing is adjusted in the factory to the normal level at approximately 25°C. Unless there is subsequent mechanical damage to the bushing, which results in loss of oil, the filler level should be satisfactory for the life of the bushing. Since fluctuations in oil level will necessarily occur with changing temperatures, the column of oil in the bushing is topped with a compressible cushion of nitrogen gas to fill the space above the oil.

All bushings are equipped with an amber-tinted, extra-heavy-walled sight glass as shown in Figure 3. The actual oil level is visible through the glass and is readily distinguishable by the apparent magnification of the center conductor below the oil surface. The normal liquid level is slightly below the mid-point of the sight glass, although a bushing is considered to have a satisfactory liquid level when any amount of oil is visible in the sight glass.

When low oil level is indicated, examine the bushing for possible loss of oil which could result in eventual failure. A low level exists when the oil level is not visible in the sight glass.

WARNING

DO NOT OPERATE OR TEST A BUSHING WITH THE INTERNAL BUSHING OIL LEVEL BELOW THE SIGHT GLASS. THIS COULD RESULT IN SERIOUS DAMAGE TO THE BUSHING, APPARATUS ON WHICH THE BUSHING IS MOUNTED, AND/OR THE TESTING EQUIPMENT BEING USED. OPERATION COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.

CONNECTIONS

Internal Electrical Connections

The method used in making connections between a bushing and the apparatus on which it is mounted will depend upon the type of connection used in the apparatus.

Draw Lead Connected Bushings

Bushings with a current rating of 400 amperes are designed with a hollow conductor through which a flexible cable can be pulled. The cable is considered a component of the apparatus on which the bushing is mounted and is not supplied as a part of the bushing.

For bushings with current ratings of 400/1200, refer to Figure 5A. Remove the top terminal, the retaining pin, and the draw lead stud. Pass a wire or cord through the bushing center conductor and attach it to the hole in the top end of the draw lead stud on the flexible transformer cable. Lower the bushing into the opening in the cover, simultaneously pulling the cable up through the center conductor. Secure the draw lead stud to the center conductor by replacing the retaining pin and threading on, and tightening, the draw lead nut. Avoid excessive tightening since it will only bend the retaining pin.

For bushings with a current rating of 400 amperes (draw lead only bushings), refer to Figure 5C. Remove the top terminal, the retaining pin, and the draw lead stud. Pass a wire or a cord through the bushing center conductor and attach it to the hole in the top end of the draw lead stud on the flexible transformer cable. Lower the bushing into the opening in the cover, simultaneously pulling the cable through the conductor. Secure the draw lead stud to the center conductor by replacing the retaining pin.

Bottom Connected Bushings

Bushings rated 1200 amperes and higher, Figure 5B, are designed to carry the current through the center conductor. A circuit breaker interrupter or transformer terminal may be connected to the threaded extension of the center conductor at the bottom end.

TOP TERMINAL TIGHTNESS

Before assembling the top terminal, make sure the threads on the mating parts are clean. If not, clean the threads with a wire brush. Apply petroleum jelly on the threads before assembly.

Coat the gasket with a thin film of transformer oil or petroleum jelly and assemble in position as shown in Figures 5A, 5B or 5C. Screw the top terminal onto the draw lead stud for draw lead bushings (Figure 5C) or the center conductor for interchangeable bushings (Figure 5A or 5B) until a metal to metal seat contact is made. Tighten the terminal as per the torque values given in the following table.

The following torque values will normally provide adequate tightness of the terminal caps.

TOP TERMINAL SIZE Inch-Thread	TORQUE ft-lb (N-m)
1.125 - 12	35 (48)*
1.5 - 12	100 (136)**

* 400 amp draw lead only

** TBI bushings. See Figures 5A and 5B.

Gaskets shown in Figures 5A, 5B and 5C are provided for seal and protection of internal threads against corrosion. If these gaskets are damaged or become hard and lose their resiliency, they should be replaced promptly. USE FACTORY SUPPLIED GASKETS ONLY. DO NOT SUBSTITUTE WITH ANY OTHER TYPE, OR MATERIAL.

TIGHTNESS OF THE TOP TERMINAL IS ESSENTIAL FOR TROUBLE FREE OPERATION AND MUST BE ENSURED AT THE TIME OF INSTALLATION AND CHECKED PERIODICALLY DURING SERVICE. REFER TO THE SECTION ON "MAINTENANCE" FOR DETAILS.

EXTERNAL ELECTRICAL CONNECTIONS

The external connection to the bushing must be sufficiently slack or flexible to avoid putting a mechanical strain on the bushing parts.

Terminal connectors should be of ample size to keep the bushing terminal temperature below 70°C at rated current. The use of even more generously sized connectors is recommended to minimize bushing overheating during possible overloads.

DO NOT LOOSEN THE TOP TERMINALS WHEN INSTALLING LINE TERMINAL CONNECTORS.

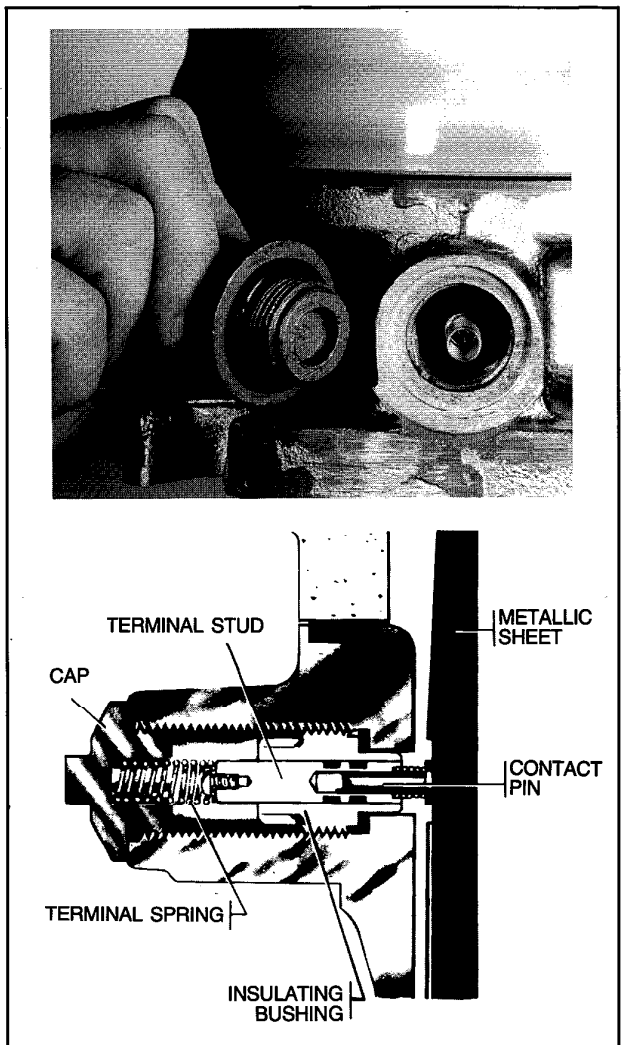


Figure 4: Bushing Test Tap.

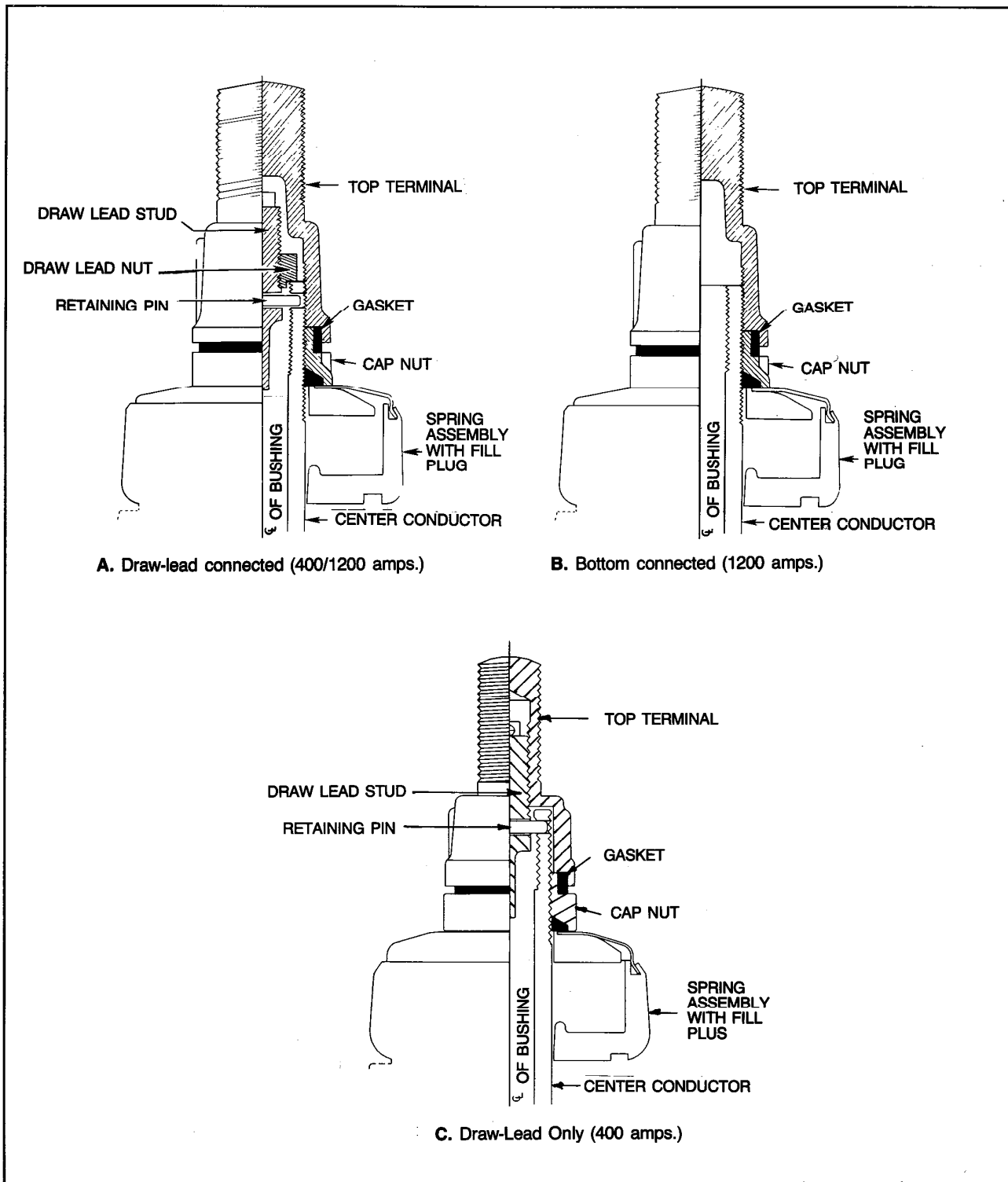
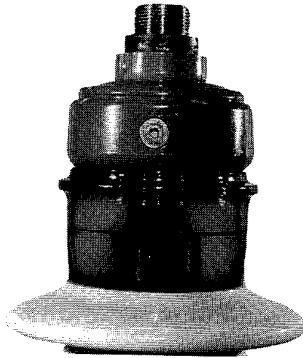
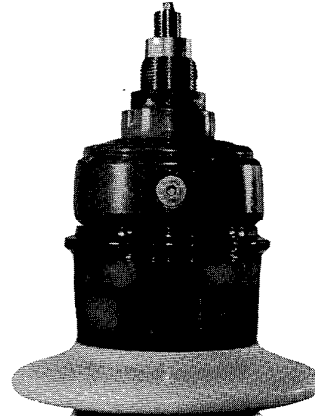


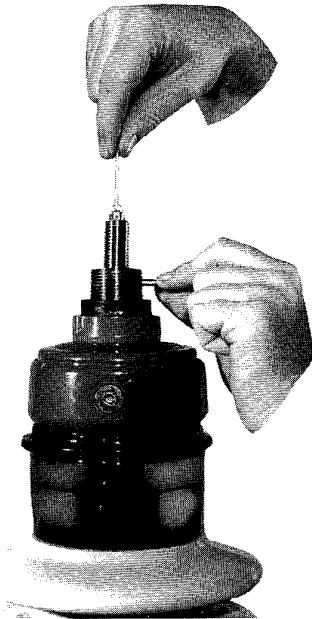
Figure 5: Top end construction for 400/1200 ampere, Type "O Plus C" bushing.



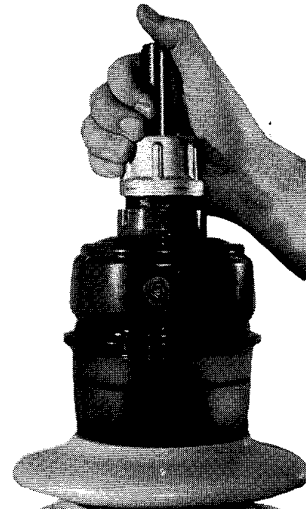
A. Top terminal removed



C. Draw lead nut threaded on draw lead stud



B. Pulling draw lead through and pinning draw lead stud in place.



D. Assembling top terminal

Figure 6: Converting bushing from bottom end to draw lead connected use.

BUSHING TEST TAP (And Power Factor/Capacitance Measurements)

The outlet shown in Figure 4 is located just above the mounting flange and provides a convenient means for making power factor and capacitance measurements by the ungrounded specimen test (UST) method. In order to connect to the tap outlet, remove the threaded cap and connect the UST lead of the power factor measuring equipment to the terminal spring.

After the testing has been completed, reassembly of the sealing cap will ground the power factor test tap for proper operation of the bushing.

Many bushing users measure the UST power factor and capacitance at the time of installation. We endorse this practice and it is discussed in more detail under "Maintenance."

CAUTION

DO NOT APPLY VOLTAGE TO THE BUSHING WITH THE TEST TAP CAP REMOVED, EXCEPT WHEN MEASURING POWER FACTOR. IF THE TAP CONNECTION IS NOT GROUNDED, THE TAP VOLTAGE WILL EXCEED THE INSULATION DIELECTRIC STRENGTH, RESULTING IN A FLASHOVER. THE VOLTAGE ON THE TEST TAP MUST BE LIMITED TO ONE kV FOR REVERSE UST TESTS.

TRANSFORMER-BREAKER INTERCHANGEABLE (TBI) BUSHINGS

An outstanding feature of this line of bushings is that a 1200 ampere, bottom connected bushing is also a 400 ampere draw lead connected bushing for transformer use.

Conversion

A series of photographs (Figure 6) shows the step-by-step procedure for conversion of a bottom end connected bushing to draw lead connected.

Proceed as follows:

1. Remove the top terminal.
2. Pull up the transformer draw lead with the attached stud through the conductor tube.
3. Insert the retaining pin.
4. Thread on a draw lead nut, and tighten to 35 ft-lb (48 N-m) torque.
5. Assemble the top terminal with its gasket. Refer to section on "Top Terminal Tightness".

Ampere Ratings

Interchangeable bushings are available in current ratings of 400/1200 amperes. ALL DRAW LEAD TYPE BUSHINGS ARE LIMITED TO OPERATION AT 400 AMPERES.

In the case of draw lead accessories, the current flow is from the transformer draw lead to the stud, through the threads to the contact nut and through the center conductor threads to the top terminal.

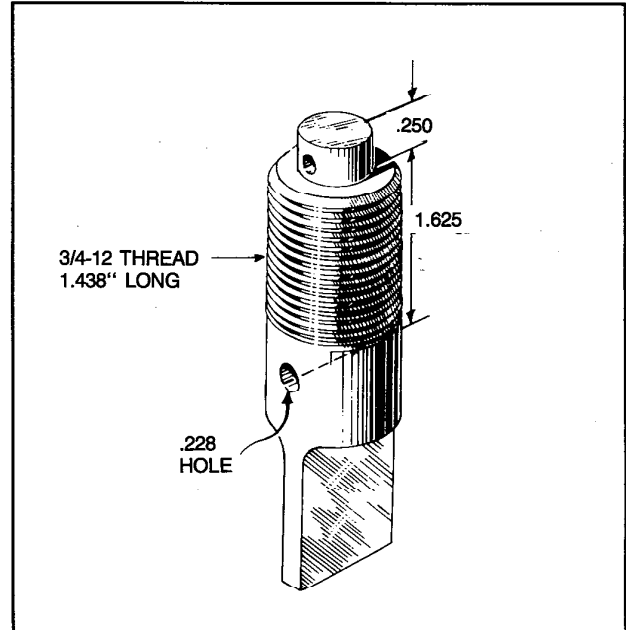


Figure 7: Draw lead stud.

The nameplate lists two current ratings. The 400 ampere rating is maximum for draw lead application and the 1200 ampere rating is maximum for bottom end connected application.

Draw Lead Terminal Stud

The draw lead terminal stud (Figure 7), used in TBI bushings is of the same general type used throughout the industry for many years. Unfortunately, not all such studs are identical in length. Due to the limited clearances of this line of bushings, the length of the threaded draw lead stud is critical. The critical dimensions of the stud furnished with the bushing are shown in Figure 7. Any suitable copper stud that complies with the dimensions can be used.

NAMEPLATE DATA

Nameplate data is especially important in answering questions about bushings.

All requests will be expedited if the factory is furnished the serial number, the catalog number, the functional style number, and the year of manufacture as stamped on the bushing nameplate. **IT IS ABSOLUTELY NECESSARY FOR THE FACTORY TO HAVE AT LEAST THE SERIAL NUMBER.**

The functional style number identifies the bushing by type and rating. When corresponding with the factory, provide the complete functional style number and/or catalog number information shown on the nameplate. All bushings of the same functional style number or catalog number are completely interchangeable.

A careful record should be kept for the interchangeable bushings. Complete information about the application of the bushing must be given in any correspondence with the factory.

ORDERING ACCESSORIES

Accessories may be taken from bushings being replaced in the field, or may be ordered from the factory. When ordering, give the following information:

1. Catalog or style number and version number of the bushing being converted.
2. Type of apparatus on which the bushing will be used.
3. Current rating of the bushing as it will be used.

MAINTENANCE

Little maintenance is required other than periodically checking the oil level as indicated in the sight glass, measuring the power-factor, and noting the condition of the top terminals. Bushings exposed to salt spray, cement dust, and other abnormal deposits are subject to a special hazard and must be cleaned regularly to prevent flashover and corrosion of parts.

Metal parts are painted for protection against the weather. Care should be taken to prevent scratching these painted surfaces. Refer to the "Painting" paragraph.

The sight glass transparency may become impaired due to reaction with atmospheric contaminants and should be cleaned regularly to deter this reaction. If the sight glass does become opaque, the bushing should be replaced.

In the unlikely event it becomes necessary to add oil to a bushing, the fill plug in the spring assembly can be removed. Insertion of a clean standpipe, with an outside diameter of slightly less than the diameter of the hole, will provide a means of adding small quantities (one quart or less) to the bushing. This should return the oil to the proper level. If not, the bushing must be removed from service and returned for repair and processing. Follow the procedure outlined below for oil addition in the field.

Obtain the necessary oil from the Components Division Plant, Alamo, TN 38001, or provide oil that meets the following standard:

Transformer oil (PDS 55822AG) processed to have additional requirements of:

1. Moisture content less than 5 PPM
2. Neutralization less than 0.02 Mg KOH/g
3. Dielectric breakdown min. 45 kV ASTM D 877
4. Power factor less than 0.05%

To prevent oxidation of the bushing oil, the air space above the oil level should be purged with dry nitrogen and the fill plug replaced immediately afterward.

WARNING

DO NOT REMOVE THE FILL PLUG WHEN THE BUSHING IS AT AN ELEVATED TEMPERATURE AS THE OIL INSIDE THE BUSHING MAY BE VERY HOT AND AT HIGH PRESSURE. MAKE SURE THE BUSHING TEMPERATURE IS IN THE 15 TO 35 DEG. C RANGE. FAILURE TO FOLLOW THESE GUIDELINES COULD RESULT IN SEVERE PERSONAL INJURY.

Since inconvenient service interruptions result from bushing outages, many users have programs of Planned Preventative Maintenance. We endorse such programs and recommend:

1. Measurement of power factor and capacitance at the time of installation and repeating the measurements annually.

Field measurements of power factor and capacitance can differ from measurements made under the controlled conditions in the factory. The bushing power factor and capacitance should be measured at the time of installation and these values should be used as a base to compare with future measurements. Contact your ABB Power T&D Company Inc. representative for corrective action procedures if:

- a. The power-factor doubles the original installation value; or
- b. The capacitance increases to 110 percent of the original installation value.

A test tap is located on the bushing flange as shown in Figure 2. Details of this device can be seen in Figure 4. This device provides access to the bushing condenser through the normally grounded flange.

The following guidelines may be used to minimize the effect of contamination and high humidity during power factor and capacitance measurements in the field.

- a. Clean the bushing thoroughly with a suitable cleaner to remove any contaminants that may have deposited on the porcelains and other parts during shipping or storage. After cleaning, wipe dry the surface to avoid moisture condensation.
- b. Clean and dry the test tap insulator to remove any contamination or condensation.
- c. Avoid making power factor measurement in wooden crates to minimize the effect of surface leakage due to moist wood.
- d. Provide sufficient clearance between the bushings and other objects to minimize the effect of stray capacitance.
- e. Do not invert bushing as this may cause entrapment of gas and result in erratic readings.
- f. For information on ground connections and other guidelines, please refer to the test equipment manufacturer's Instruction Manual.

2. Examination of the top terminals for loose connections and overheating.

For satisfactory operation of a bushing, it is important that the top terminals are tight at all times. If any of these parts are loose, overheating of the current carrying joint can take place and result in damaged terminal joints. This type of overheating can deteriorate the bushing gasket seals which could result in deterioration of the oil-paper system.

Visually examine the bushings and look for discolored top terminal, external terminal connector or bolts. Look for steam rising from the terminal during rain. Perform an infrared scan of the top terminals.

If the above examination indicates overheating, remove the transformer from service and check the power factor and capacitance. Refer to section on "Maintenance" for guidelines on power factor and capacitance measurements.

If the top end parts are discolored, then check the terminals as per the following:

Remove the top terminal and examine for any damage. Examine the gaskets for any sign of hardening. If any signs of overheating are present then the bushing should be taken out of service as the overheating may have affected the other sealing gaskets at the top end.

If the top terminal can not be removed, it has most likely suffered overheating damage at the threaded joint. Remove the bushing from service.

If the top end parts do not show any sign of overheating or damage and the power factor and capacitance values are acceptable, then reinstall these parts by following the instructions in the section on "Connections". Use new gaskets if they show any sign of damage.

**FOR SPECIFIC RECOMMENDATIONS PLEASE CONTACT
ABB POWER T&D COMPANY INC.**

FIELD REPAIRS

Any repair of Type "O Plus C" bushings should be done in the factory because of the danger of contamination to the insulation if the seal is broken. In addition, the very high vacuum and clamping pressure require the use of equipment not usually available in the field.

Any damage to a bushing which might make repair either desirable or necessary, should be reported to the factory. **DO NOT ATTEMPT TO REPAIR A TYPE "O PLUS C" BUSHING WITHOUT SPECIFIC RECOMMENDATIONS FROM THE ABB POWER T&D COMPANY INC.**

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IL 44-665D 4/93
Supersedes IL 44-665C 1-2-90

APRIL 1993
Printed in U.S.A.