Bushings

44-666G
Instruction Leaflet

Instructions for Installation, Maintenance and Storage of Type "O Plus C" Bushings 115 kV and Higher

February 1, 1994
Supersedes IL 44-666F
Dated September 1990

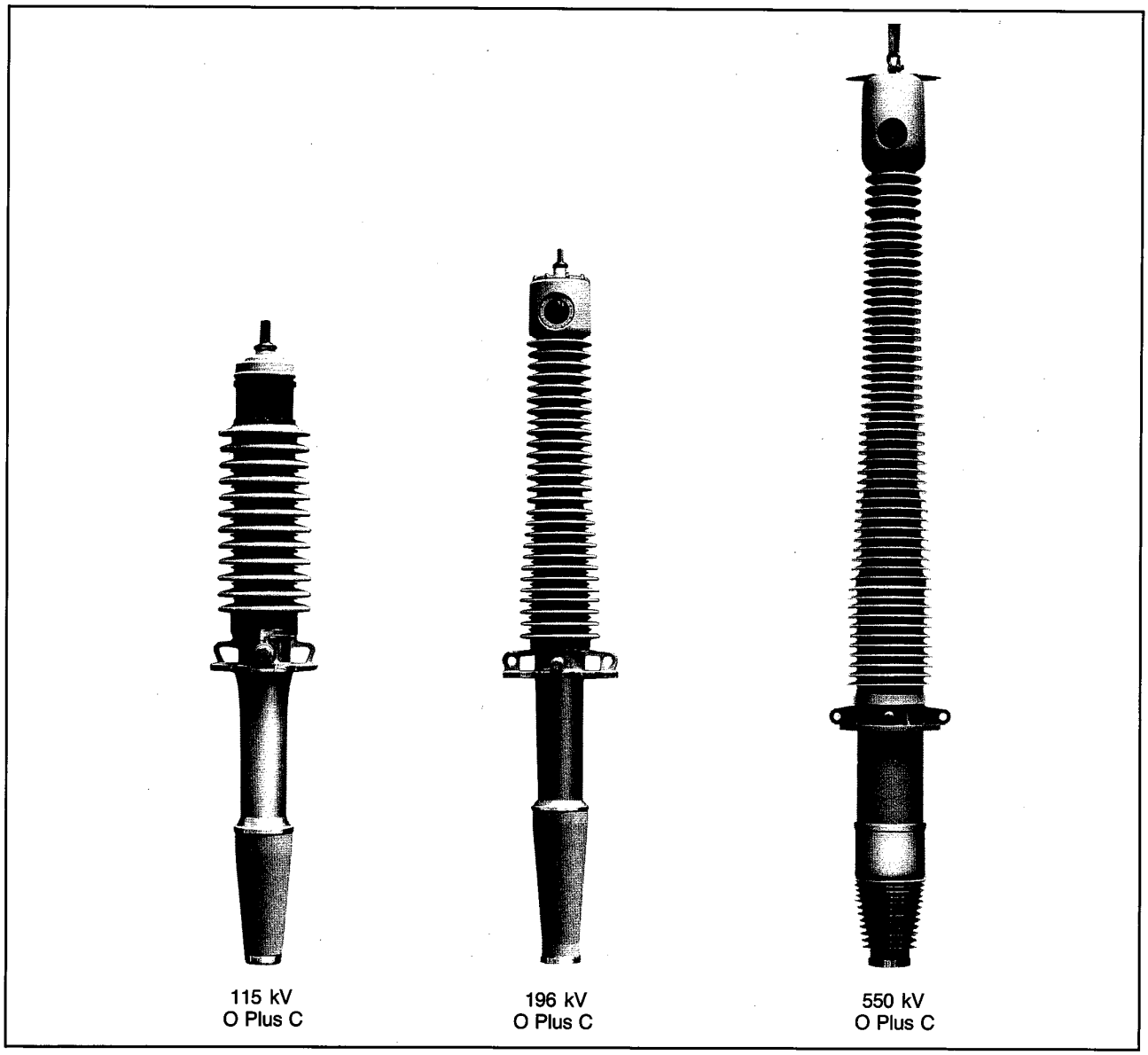


Figure 1: Typical Type "O Plus C" bushings

ABB Power T&D Company Inc.

ASEA BROWN BOVERI

SCOPE

This leaflet contains general procedures to be followed from the time the bushings are received until they are put into operation. These instructions do not purport to cover all possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment. The outline drawing contains pertinent information, for a specific bushing, required for safe and proper installation and application. Review the outline thoroughly before installing or energizing a bushing. If you require further information regarding this installation or the operation and 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. Type "O PLus C" condenser bushings are manufactured exclusively at the Components Division Plant in Alamo, Tennessee.

Type "O Plus C" condenser bushings (Figure 1) 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 metal or glass expansion domes. This cavity along with the condenser is evacuated and then filled with highly processed tranformer oil for a very low moisture content and low bushing power-factor. This low moisture content and low power-factor is maintained throughout the life of the bushing by permanently sealing the bushing cavity. Spring loaded center clamping hardware is used to apply sufficient clamping pressure to seal the bushing cavity during manufacturing. This 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 Leaflet, 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 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 138 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. Horizontal shipment or storage is limited to bushings rated 138 kV and below. Bushings rated above 138 kV must have the top end elevated during shipment and storage.

2. The bushings can be shipped in a horizontal position to the ultimate destination if the maximum period in transit does not exceed 15 days.

3. The bushings can then be stored in a horizontal position for a maximum period of 15 days.

4. 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. Gently rock the bushing to release any nitrogen gas that may have been trapped in the insulation.

5. If the bushings are in transit or are stored in a horizontal position exceeding the time in these guidelines, contact Customer Service, Components Division, Alamo, TN 38001, telephone (901) 696-5561. Reimpregnation of the condenser at the factory will be required if the specified time periods are exceeded.

6. Bushings should be shipped in their own crates. Generally two supports are necessary for shipping bushings. One support is under the flange and the other is under the metal expansion chamber or the upper porcelain. Bushings rated 500 kV and above may need an extra support under the upper porcelain.

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

RECEIVING

When a bushing is received, it should be examined for 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. Sales Representative immediately.

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

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 cause for concern, the following information should be considered.

1. Type "O Plus C" bushings are oil pressure tested at 22 psig during manufacture.

2. The presence of an oil film on the surfaces or joints 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 and 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 in the gage.

STORING

A Type "O Plus C" bushing can be stored outdoors in the shipping crate for short periods (Figures 2, 3, 4 show shipping crates).

For long term storage, a bushing should be stored in a vertical position in a clean dry place.

If a bushing must be stored in a position other than the vertical, adequate oil coverage must be provided by positioning the upper end above the lower end. An angle of seven degrees or higher above the horizontal must be maintained. Bushings rated 115 kV and above are generally shipped with their top end elevated to assure coverage of the condenser insulation. These bushings can be stored in their skids for long periods.

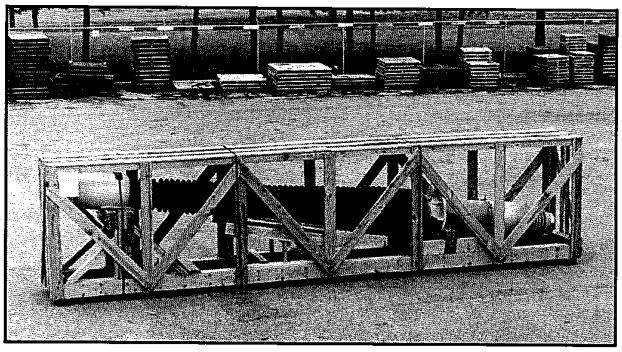


Figure 2. Shipping crate for bushings up to 345 kV.

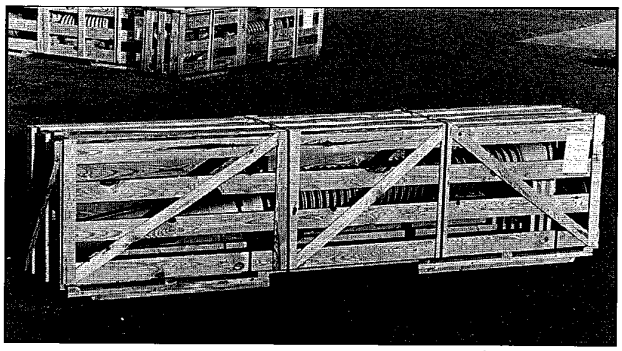


Figure 3. Shipping crate for bushings above 345 kV.

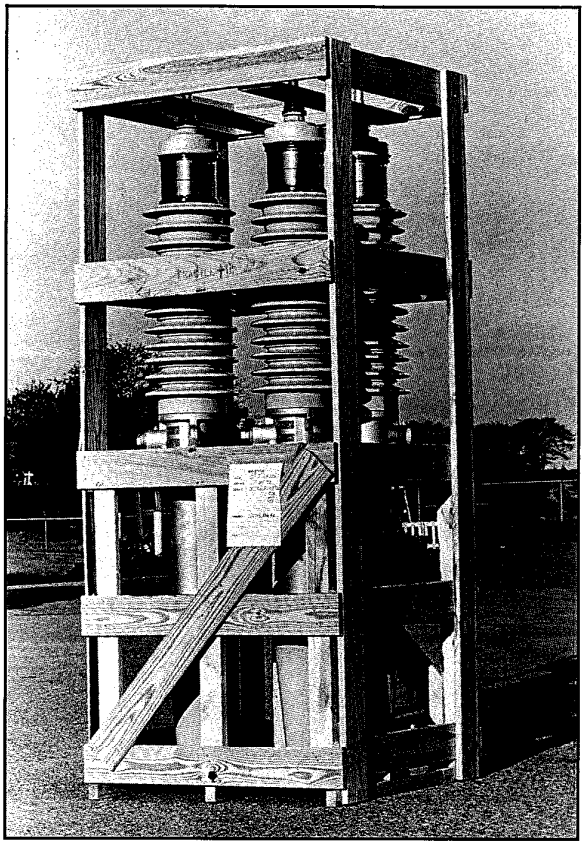


Figure 4. Bushing shipping crate for upright shipments.

For long term storage, suitable protection should be provided for terminals and mounting hardware. The gasket surface on the underside of the mounting flange should be heavily greased to protect it from rusting and corrosion. The potential tap housing should be filled with clean, dry transformer oil by removing the filler plug. (Item 17, Figure 14) to prevent condensation and corrosion. When filling, leave a space of one quarter of an inch in the chamber for oil expansion. Coat the threads on the filler plug with a suitable sealer and replace the plug in the filling hole. Be certain that the plug is tight.

HANDLING AND MOUNTING

Bushings rated 115 kV and above are provided with lifting eyes in the flange. Because of the weight and dimensions, the main lifting tackle should always be attached to the lifting eyes. These bushings are shipped in special crates that hold the upper end above the lower end. A seven degree or a greater angle must be maintained to prevent any entrapment of gas in the insulation.

Before lifting the bushing, remove any banding iron, clamps, or mounting flange bolts holding the bushing to the skid or the shipping crate.

WARNING

BEFORE LIFTING THE BUSHING FROM THE CRATE THE PORCELAIN SHOULD BE INSPECTED THOROUGHLY FOR CRACKS AND DAMAGE AS PERSONAL INJURY OR PROPERTY DAMAGE MAY OCCUR IF THE PORCELAIN BREAKS DURING THE LIFTING PROCESS.

1. Bushings Rated 550 kV and Higher

Before lifting the bushing from the shipping skid/crate, remove any shipping flange bolts holding the bushing to the skid.

a. These bushings are provided with two guide brackets bolted to the top of the metal dome which should only be used to guide the slings during lifting. Use two crane hooks to lift the bushing as shown in Figure 5.

b. Attach two slings to one crane hook. Pass the other ends of the slings through each of the upper guide brackets. Use a spreader bar to keep the slings parallel above the guide brackets. Attach the lower ends of the slings to mounting flange lifting lugs 180 degrees apart. Use shackles in the lifting lug eyes.

c. Attach a sling to the second crane hook. Attach the other end to a shackle. Attach this shackle to the third mounting flange lifting lug located between the other two lifting lugs.

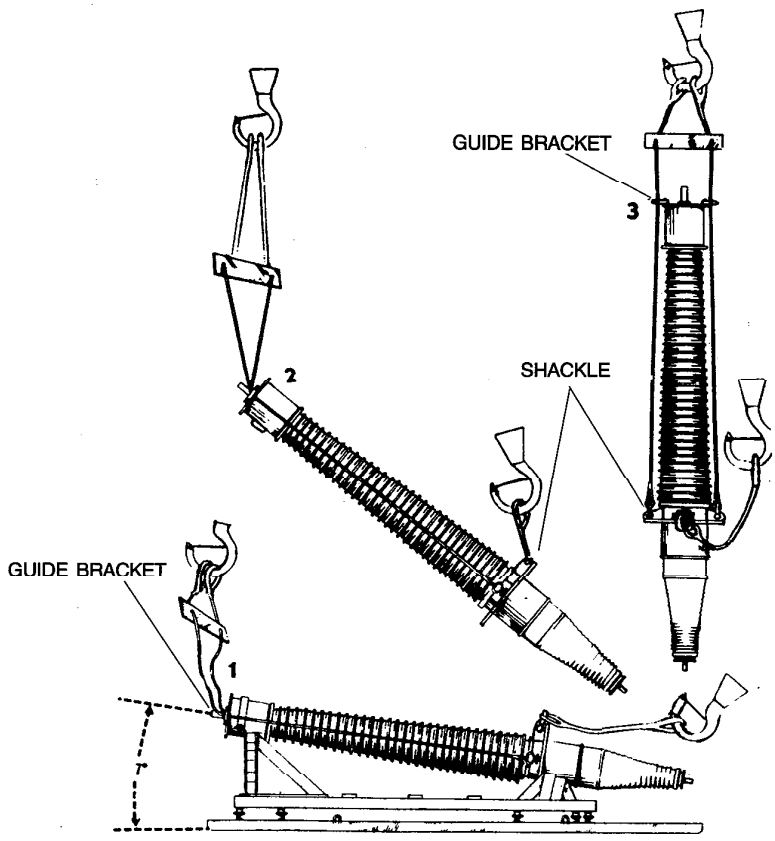
d. Lift the bushing by raising both the crane hooks simultaneously maintaining the seven degree or greater angle.

e. For mounting the bushing at an angle, raise or lower the crane hooks to get the desired angle. These bushings are provided with a magnetic oil level gage. The bushing should be mounted with the gage facing downwards as shown in Figure 7 for proper oil level indication.

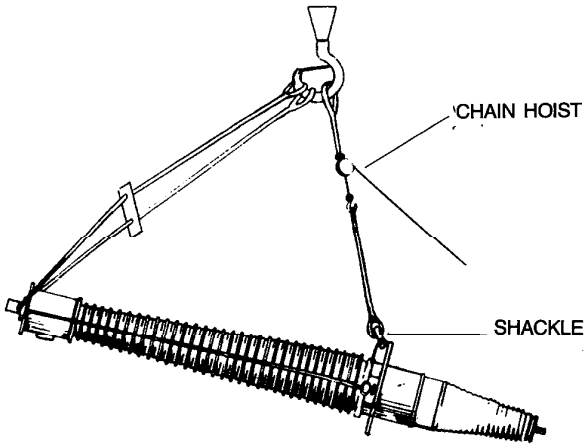
Note; We recommend using two crane hooks while lifting a bushing. If these are not available then a single crane hook can be used with a chain hoist as shown in Figure 6.

WARNING

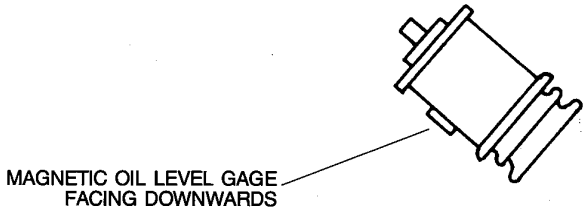
THE UPPER GUIDE BRACKETS ARE PROVIDED FOR GUIDING THE LIFTING SLINGS ONLY AND MUST NOT BE USED FOR LIFTING THE BUSHING. REMOVE GUIDE BRACKETS, SHIPPING BANDS, AND ANY OTHER SHIPPING HARDWARE BEFORE ENERGIZING THE BUSHING.



5. Method of lifting a bushing rated 500 kV and above.



6. Method of lifting a bushing rated 500 kV and above using one crane hook and a chain hoist.



7: Orientation of magnetic oil level gage on bushing rated 500 kV and above when mounted at an angle.

Figures 5, 6 and 7: Method of lifting a bushing.

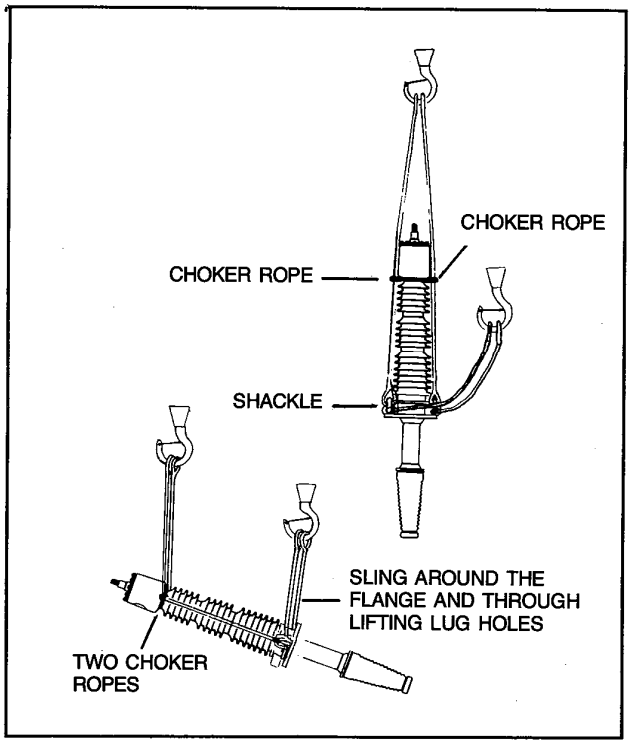


Figure 8: Method of lifting a bushing rated 362 kV and below.

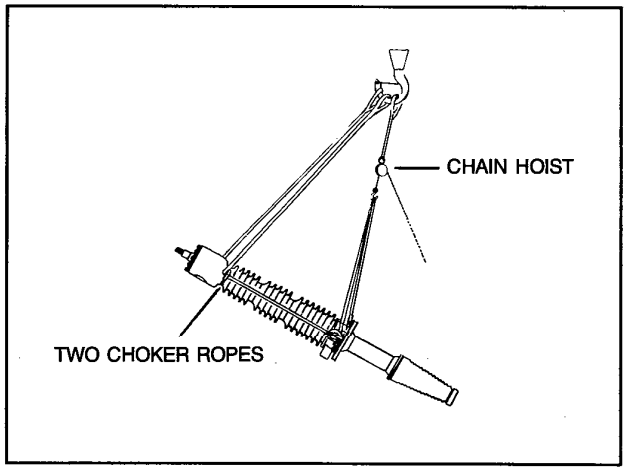


Figure 9: Method of lifting a bushing rated 362 kV and below using one crane hook and a chain hoist.

2. Bushings Rated 362 kV and below

a. Bushings rated 362 kV and below can be lifted as shown in Figure 8. Unlike bushings rated 550 kV and higher, these bushings do not have guide brackets bolted at the top and therefore two nylon choker ropes/slings should be tied around the top porcelain just under the metal dome or under the first porcelain shed on bushings without metal dome to guide the lifting sling on each side.

b. Attach two slings to one crane hook. Pass the other ends of these slings through the eye of each choker rope/sling. Attach a shackle to each of these slings. Attach the shackles to the two mounting flange lifting lugs 180 degrees apart.

c. Pass a sling through the hole in each of the two mounting flange lifting lugs and then attach the two ends of the sling to the second crane hook.

d. Lift the bushing by raising both the crane hooks simultaneously maintaining the seven degree or greater angle.

e. When a bushing has to be mounted at an angle, it should be lifted as shown in Figure 10. Attach a sling to a crane hook. Pass the other end of this sling through the eye of a choker rope/sling tied around the porcelain just under the dome or under the first porcelain shed on a bushing without the metal dome. Attach a shackle to this sling and then attach this shackle to the mounting flange lifting lug. Pass a sling through the hole in each of the two lifting lugs and then attach the two ends of this sling to the second crane hook. Mount the bushing by raising or lowering the crane hooks.

Bushings rated 161 kV thru 362 kV are provide with prismatic glass oil level gages. This gage should be oriented towards the side as shown in Figures 10 and 11 for proper oil level indication.

Note: We recommend using two crane hooks while lifting or mounting a bushing. If these are not available then a single crane hook with a chain joist can be used as shown in Figure 9 and 11.

3. Angle of Inclination

Bushings with cylindrical oil level sight glasses may be mounted at any angle up to 60 degrees from vertical. Bushings with magnetic oil level gages and those with prismatic glass oil level gages should not be used at angles exceeding 20 degrees from the vertical. Refer to the outline drawing for specific information. All other applications should be referred to the factory.

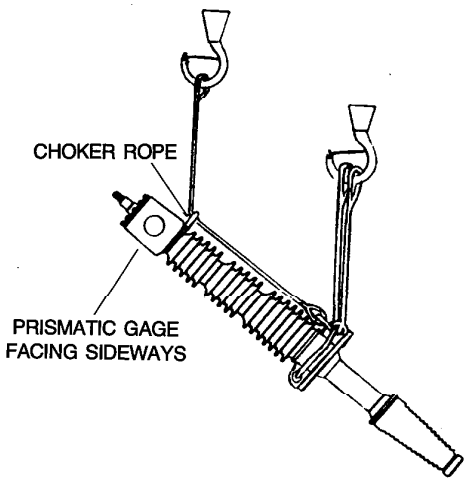


Figure 10. Method of mounting a bushing at an angle and orientation of the prismatic glass oil level gage.

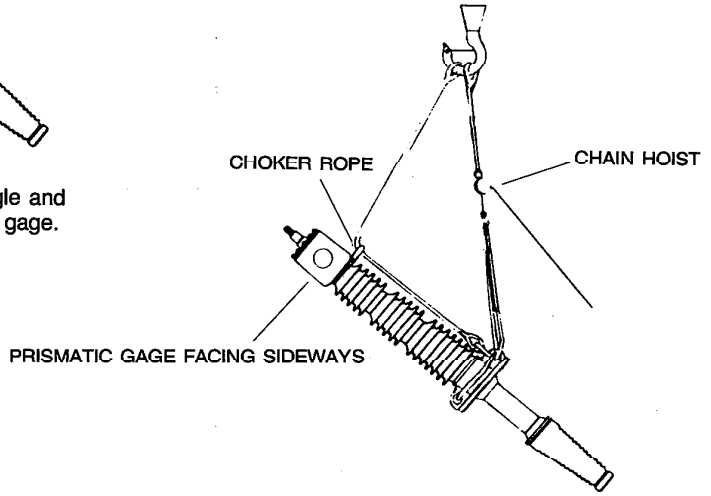


Figure 11. Method of mounting a bushing rated 362 kV and below using one crane hook and a chain hoist.

Figures 10 and 11: Method of mounting bushings at an angle.

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. The capacitance and power factor of the bushing should be measured in accordance with the "CAPACITANCE TAP AND POWER FACTOR MEASUREMENT" section of this leaflet prior to energizing. After uprighting the bushing, check to insure the internal bushing oil is at the proper level. Always allow the bushing to equalize to the temperature of the apparatus on which it is being installed prior to energization.

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)
3/4 - 10	35 (48)

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.

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 current ratings of 800 amperes are generally 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 with the bushing.

Refer to Figure 12. Remove the top terminal, the retaining pin, and the draw lead stud. Before installing the draw lead, make sure that the draw lead cap is screwed tightly into the clamping cap or the center conductor. Tighten the draw lead cap with a torque of 120 ft - lbs. Pass a wire or cord through the bushing center conductor and attach it to the hole at the top end of the draw lead stud on the flexible 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 draw lead cap by replacing the retaining pin. Refer to the paragraph on "Top Terminal Tightness" for assembly and tightening.

Bottom Connected Bushings
Bushings rated 1200 amperes and higher are designed to carry the current through the center conductor. A circuit breaker interrupter or transformer terminal may be connected to the lower support of the bushing. Figure 15 shows different arrangements for bottom connections. Figures 15B and 15D show a bevelled machine surface with a four inch spherical radius as per Table 6 Figure 2 and 3 IEEE C57.19.01. This surface is designed to carry current when in contact with a bevelled surface on the bottom terminal. Figure 15F shows an example of a transformer bottom end connection.

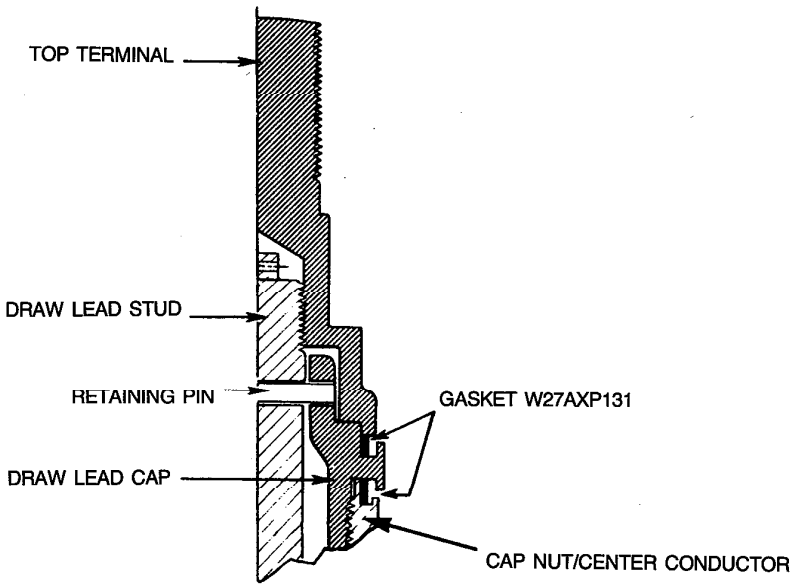
Top Terminal Tightness
Before assembling the top terminal, make sure that the threads on the mating parts are clean. If not then clean the threads with a wire brush. Apply petroleum jelly on the threads before assembly.

Coat the gasket with a thin film of transformer oil or petroleum jelly and assemble in position as shown in Figures 12 or 13. Screw the top terminal onto the draw lead stud for draw lead bushings (Figure 12) or into the cap nut or center conductor for bottom end connected bushings (Figure 13) until a metal to metal seat contact is made. Tighten the terminal as per the torque values given in the following table.

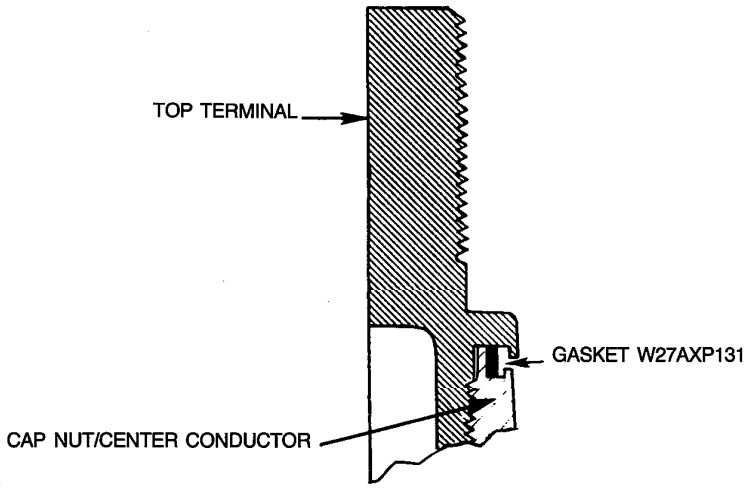
The following torque values will normally provide adequate tightness of the top terminals.

TOP TERMINAL SIZE Inch-Thread	TORQUE ft-lb (N-m)
1.125 - 12	100 (136)
1.5 - 12	100 (136)
2.0 - 12	100 (136)
3.0 - 12	100 (136)

Gaskets shown in Figures 12 and 13 are provided for proper 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.



12. For draw-lead connected bushing.



13. For bottom connected bushing.

Figures 12 and 13: Details of the end construction.

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.

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 gas space above the oil.

Figure 14 shows alternate ways of indicating the oil level in bushings rated 115 kV and above.

The actual oil level can be seen on a bushing equipped with a sight glass, Figure 14A, or a prismatic oil level gage shown in Figure 14B. As long as the oil level can be seen, the level is at a satisfactory height.

When a low oil level is indicated, examine the bushing for possible loss of oil which could result in eventual electrical failure. A low level exists when the pointer on a float type indicator is on "Low" or when the level has disappeared below the sight glass or prismatic gage.

WARNING

DO NOT OPERATE OR TEST A BUSHING WITH A LOW INTERNAL OIL LEVEL. 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.

BUSHING VOLTAGE TAP

A standard Type, "O PLus C" bushing rated 115 kV and higher has a small housing containing a voltage tap outlet just above the mounting flange. The terminal in the tap is grounded by means of a spring clip in the tap cover. While the purpose of the tap is to provide connection to a bushing potential device, it also provides a convenient means for making connections for measuring power-factor and capacitance by the UST (Ungrounded Specimen Test) method.

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

When a connection is to be made to the voltage tap, either for use with a potential device or for power factor measurement, open the housing by removing the tap cover (Item 19, Figure 14). Assemble the potential device connection or proceed with the power factor measurement.

After the power factor measurement is completed and if there is no connection to a potential device, remove the test connection and close the housing by replacing the tap cover. Be certain the cover is on tight.

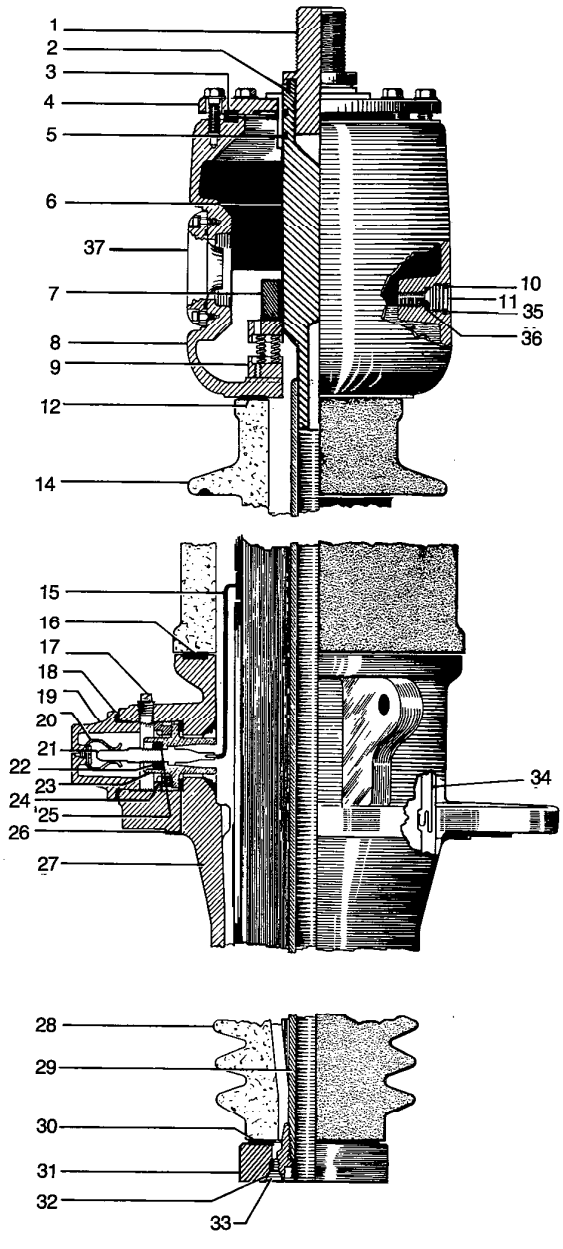
If the voltage tap is used for a connection to a potential device, after the connection is assembled, remove the filler plug (Item 17, Figure 14) and fill the chamber with clean, dry transformer oil. Leave an expansion space of approximately one quarter of an inch at the top of the chamber when you fill it. Coat the threads on the filler plug with a suitable sealer and replace the plug in the filling hole. Be certain the plug is tight.

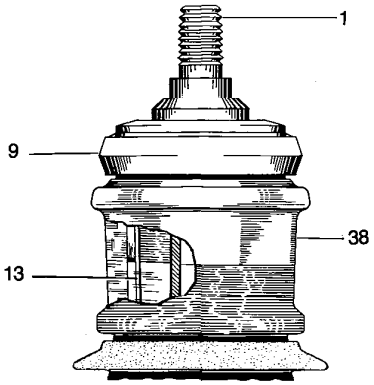
WARNING

DO NOT APPLY VOLTAGE TO THE BUSHING WITH THE VOLTAGE TAP COVER REMOVED, EXCEPT WHEN USING THE BUSHING WITH A POTENTIAL DEVICE OR WHEN MEASURING POWER FACTOR. IF THE TAP IS NOT GROUNDED, THE VOLTAGE MAY EXCEED THE INSULATION DIELECTRIC STRENGTH, RESULTING IN A FLASHOVER. THE VOLTAGE ON THE TAP MUST NOT EXCEED 5 kV WHEN MEASURING POWER FACTOR. FAILURE TO FOLLOW THESE GUIDELINES COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.

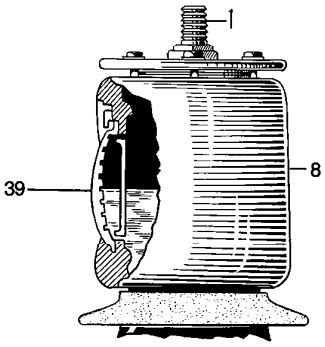
ENERGIZING

Before energizing, or the application of proof-test over voltage, keep the bushing vertical for about 48 hours.





14A. With sight glass for liquid level indication.



14B. With prismatic-type liquid level indication.

1. Top Terminal
2. Gasket
3. Gasket
4. Cover
5. Core seal gasket
6. Core extension
7. Cap nut
8. Dome
9. Spring assembly
10. Gasket (outerseal)
11. Plug (outerseal)
12. Gasket
13. Terminal shield
14. Top porcelain
15. Low voltage tap lead
16. Gasket
17. Plug
18. Gasket
19. Cover
20. Grounding spring
21. Voltage tap stud
22. Sealing nut
23. Low voltage insulator
24. Nut
25. Gasket
26. Gasket
27. Flange
28. Bottom porcelain
29. Condenser
30. Gasket
31. Lower support
32. Gasket
33. Plug
34. Ground connection
35. Gasket (innerseal)
36. Plug (innerseal)
37. Liquid level gage
38. Sight glass
39. Prismatic liquid level gage

Figure 14: Sectional view of bushing.

TRANSFORMER-BREAKER INTERCHANGEABLE (TBI) BUSHINGS

An outstanding feature of this line of bushings is that the 1200 amperes and 1600 amperes bottom connected bushings (IEEE Standard for circuit breakers) can be converted to 800 amperes draw lead connected bushings which comply with IEEE Standards for transformers.

Identifications of TBI Bushings

TBI bushings are identified by a supplementary nameplate stating "convertible — See Instruction book."

Conversion

Converting a bottom connected bushing to a draw lead connected bushing is accomplished by replacing the top and bottom terminal parts. The internal connection of the bushing to the transformer is accomplished by means of a cable which is threaded through the bushing center conductor and pinned to the draw lead cap at the top end of the bushing. The cable is a component of the transformer and is not furnished with the bushing. For assembly refer to section on "CONNECTIONS".

Conversion of a draw lead bushing to a bottom connected bushing is accomplished by reversing the procedure. A variety of bottom end constructions are shown clearly in Figure 15.

Ampere Ratings

Interchangeable bushings are available in current ratings of 800, 1200, 1600 and 2000 amperes. ALL DRAW LEAD TYPE BUSHINGS (within the scope of these instructions) ARE LIMITED TO OPERATION AT 800 AMPERES.

The illustration in Figures 12 and 13 show two possible current paths from the conductor to the top terminal.

In the case of draw lead connections, the current flow is from the transformer draw lead to the stud, through the threads, and into the top terminal. This current path is limited to 800 amperes.

In the case of bottom connected bushings, the current flow is up the center conductor of the bushing into the cap nut, through the threads, and into the top terminal. Although the top end accessories are interchangeable physically, the bushings should not be operated at currents higher than the nameplate ratings.

The maximum current rating for each interchangeable bushing is shown on the nameplate as "TRANS" for transformers, and as "OCB" for breakers. The rating applies only when the bushing has accessories for use when bottom connected. It does not apply to draw lead accessories.

CAUTION

IF THE DRAW LEAD ACCESSORIES ARE INADVERTENTLY USED WHEN THE BUSHING IS BOTTOM CONNECTED, A DISCONTINUITY IN THE CURRENT PATH MAY DEVELOP. IN THIS CASE, THE CURRENT FLOW WILL BE UP THE CENTER CONDUCTOR TO THE CAP NUT, THROUGH THE THREADS INTO THE DRAW LEAD CAP, AND ACROSS THE JOINT JUST ABOVE THE GASKET INTO THE TOP TERMINAL.

The joint above the gasket is not designed to be a current carrying contact. The draw lead top accessories must not be used when the bushing is bottom connected even at less than 800 amperes.

ORDERING ACCESSORIES

Most TBI bushings are shown on the outline drawings in pairs. One of the pair is equipped with terminals suitable for use on bottom end connection, and the other has terminals suitable for draw lead connected.

Two style numbers are assigned to the same basic design. If, at a later date, a user decides to apply a TBI draw lead bushing to bottom connected use, he must order suitable terminal parts, or he must use parts removed from the bushing being replaced. A careful record should be kept for the interchangeable bushings since complete information about the applications of the bushings must be given in any correspondence with the factory concerning the bushings.

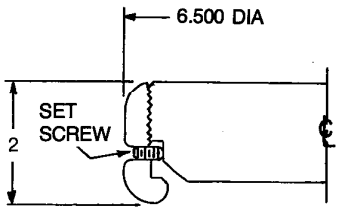
Accessories for conversion purposes may be taken from bushings being replaced in the field or may be ordered from the factory. When ordering, give the following information:

1. Style and version number of the bushing being converted.
2. Type of apparatus on which the bushing will be used.
3. BIL and current rating of the bushing.

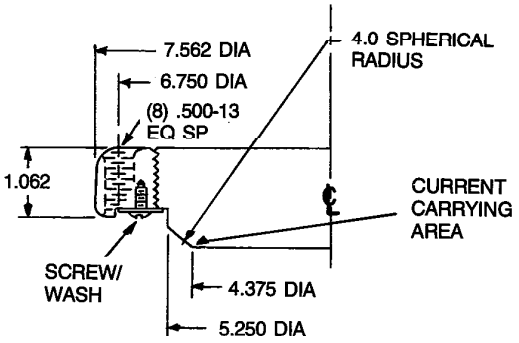
NAMEPLATE DATA

Nameplate data can be of special importance in answering questions about bushings.

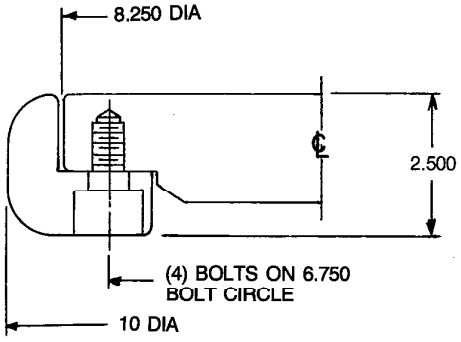
All requests will be expedited if the factory is furnished the serial number, the catalog number, the functional style number, version number, and the year of manufacture as stamped on the bushing nameplate. IT IS ABSOLUTELY NECESSARY FOR THE FACTORY TO HAVE AT LEAST THE SERIAL NUMBER.



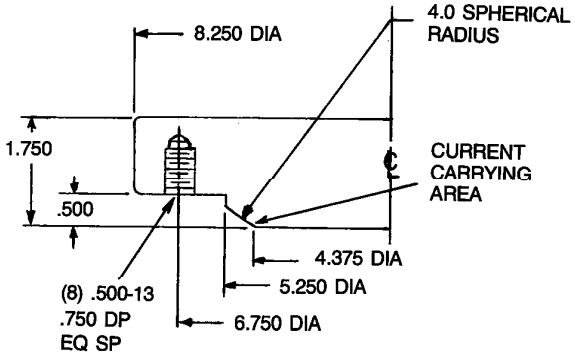
15A. TRANSFORMER DRAW LEAD
550, 650, & 750 BIL
800 AMP



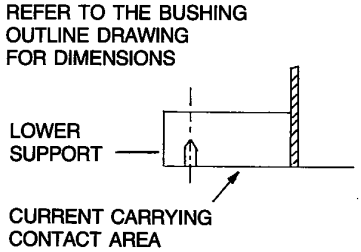
15B: TRANSFORMER OR BREAKER BOTTOM CONNECTED BUSHING
550, 650 AND 750 kV BIL
1600 AND 2500 AMP TRANSFORMER
2000 AMP BREAKER



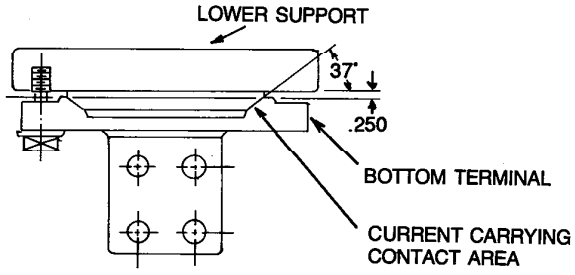
15C: TRANSFORMER DRAW LEAD BUSHING
900 BIL
800 AMP



15D: TRANSFORMER OR BREAKER BOTTOM CONNECTED BUSHING
900 BIL
1200, 1600 AND 2500 TRANSFORMER
1600 AND 2000 AMP BREAKER



15E: TRANSFORMER BOTTOM CONNECTED BUSHINGS
362 kV AND ABOVE
800 AMPS - DRAW LEAD
1600 AMPS & ABOVE TRANSFORMER



15F: EXAMPLE OF TRANSFORMER BOTTOM END CONNECTION SHOWING CONTACT BETWEEN THE TERMINAL AND THE BEVELLED SURFACE REFER TO THE TERMINAL DRAWING FOR DIMENSIONS

Figure 15: Transformer and circuit breaker bottom-end accessories.

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.

MAINTENANCE

Little maintenance is required other than periodic checking of the oil level as indicated in the sight glass or by the gage, measuring of the power-factor, and checking 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 under "Installation."

The sight glass transparency may become impaired due to reaction with atmospheric contaminants and should be cleaned regularly to deter this reaction. In the event the sight glass does become opaque, it should be replaced in order to maintain good visibility of the oil level.

In the unlikely event it becomes necessary to add oil to a bushing, the fill plug in the spring assembly or the metal dome 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 (two quarts 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 additions 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 requirement of:

1. Moisture content less than 5 PPM
2. Neutralization less than 0.02 Mg KOH/g
3. Dielectric breakdown min. 45 kV
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 UNDER HIGH PRESSURE. MAKE SURE THE BUSHING TEMPERATURE IS IN THE 15° TO 35° C RANGE. FAILURE TO FOLLOW THESE GUIDELINES COULD RESULT IN SEVERE PERSONAL INJURY.

Due to the inconvenience and possible service interruptions resulting from bushing outages, many users have programs for 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. Therefore, the power-factor and capacitance should be measured at the time of installation and used as a base to compare with future measurements. You should 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.

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 power factor 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 effects 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 connection 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, and the drawlead cap nut. 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 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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