CONDENSER BUSHINGS

INSTRUCTIONS

GENERAL

The condenser bushing is an exclusive Westinghouse development. It consists of a cylindrical condenser protected on its outer end by a wet process porcelain weather casing, which is clamped between the mounting flange and a cap. The space between the condenser and the porcelain casing is filled with a plastic or transformer oil.

This leaflet gives definite instructions for the installation, inspection and maintenance of condenser bushings. They should be inspected at regular intervals.

CONSTRUCTION

Compound Filled Bushing

Compound filled bushings have a low melting point plastic filling between the condenser and the casing.

The condenser is the heart of the bushing and consists of a central metal tube or stud upon which is wound under heat and pressure alternate layers of treated Micarta paper and metal foil. By proportioning the length and thickness of these alternate layers, a series of equal capacity condensers uniformly arranged along the length of the bushing, is formed between the central conductor and the outside layer of metal foil which is grounded. The capacities of the individual condenser elements being equal and uniformly arranged along the length of the bushing, no concentration of stresses can take place within the bushing between the conductor and grounded flange or along the porcelain casing. The condenser principle employed produces a bushing having a greater uniform factor of safety, combined with smaller dimensions, than can be obtained in other types of bushings.

The mounting flange is attached to the condenser by a mechanical press fit resulting in a joint that is permanently gas and oil tight.

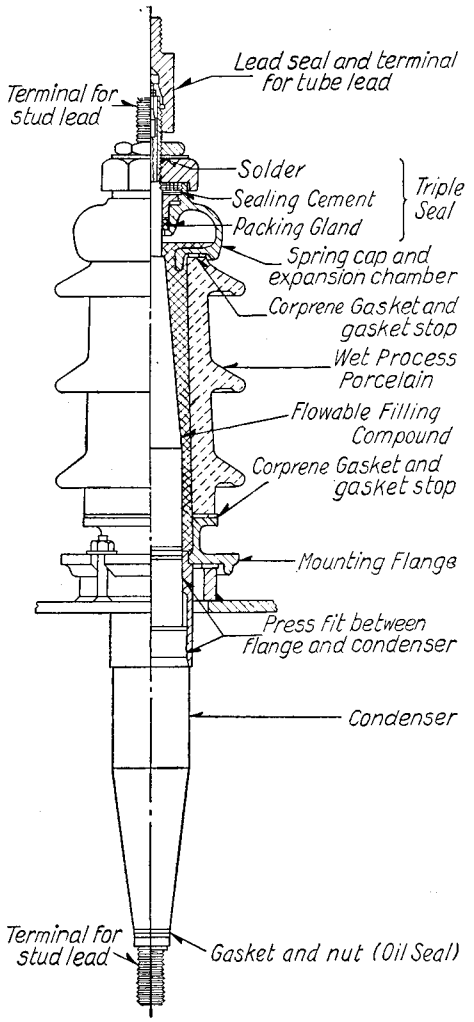

FIG. 1—PARTIAL SECTION OF TYPE G CONDENSER BUSHING

Where the ampere rating does not exceed 400 amps., provision is made for a fished through lead carried from the winding to the terminal cap of the bushing. This facilitates power factor testing. Under these conditions the central tube of the condenser of the oil encased bushing is designed with a flexible joint near the top of the expansion cap, to permit expansion and contraction with temperature, without affecting the pressure on the gaskets at the porcelain.

The weather casing is made of wet process porcelain that provides thick uniform walls, free from voids and internal stresses. The tightness of all joints is insured by having the joints gasketed with neoprene cork (with compression stops) and positive pressure on the joints at all times, secured by the spring action of the hollow metal cap. The cap also serves as an expansion chamber for the filling material, which is a low melting point plastic having high dielectric strength, high moisture resisting properties, ability to adhere to materials contacted, and characteristics so that it will not crack or fissure at low temperatures. The filling plastic is heavier than water and will not emulsify with water at any operating temperature. The cap is hermetically sealed to prevent breathing and entrance of moisture.

High voltage bushings for 92 kv. and above have steel springs in the cap. In this type of bushing the internal coil springs keep pressure on the gaskets and maintain sufficient pressure during all temperature changes. The springs do not carry current, and because of the arrangement of the materials used there is no magnetic heating. The expansion space in the cap is ample to insure that pressures built up in the bushing due to heating are of a very low order, and to prevent breathing from the outside.

Oil Encased Bushings

Although plastic encased bushings are normally used on Westinghouse transformers, occasionally, oil encased bushings may be used. The condenser and casing are the same as used in the compound filled bushings.

In the oil encased bushing the space

Condenser Bushings—Continued

INSTRUCTIONS—Continued

between the condenser and the porcelain is filled with "Wemco C" oil.

Oil encased bushings are provided with a sump or trap at the flange with a drain for sampling oil. The sump or trap will collect any moisture that might get into the porcelain column. The oil may be filtered or replaced by drawing off the oil at the flange and filling through the test plug at the cap. Removal of the oil and refilling may be done without removing the bushing from the transformer.

Oil encased bushings for 13.8 Kv. to 46 Kv. (incl.) have the type "G" cap construction as shown in Fig. 1. The 25°C. oil level is marked on the outside of the cap. The oil level may be checked by removing the test plug in the top of the cap.

Oil encased bushings for 69 Kv. and above have internal steel springs in the cap. In this type of bushing internal coil springs keep pressure on the gaskets and maintain sufficient pressure during all temperature changes. The springs do not carry current and because of the arrangement of the materials used there is no magnetic heating. The expansion space in the cap is ample to insure that pressures built up in the bushing due to heating are of a very low order, and to prevent breathing from the outside.

When the ampere rating does not exceed 400 amperes provision is made for a fished through lead as in the case of the plastic filled bushings.

An oil gauge is included on the cap of oil encased bushings of 92 Kv. and above.

INSTALLATION AND STORING

Storing Bushings—Store bushings in a dry place and keep them dry at all times. The lower end, designed to operate under oil, is not weather-proof. Remove all sawdust or excelsior from around the oil end of the bushing, before storing. Storing in vertical position is preferable. Bushings with plastic filling must be placed in vertical position in a room with temperature 70 deg. F. or higher for at least 24 hours, before being placed in operation.

Handling Bushings—Handle carefully, lift only by the lifting lugs or lifting eyes, when they are provided. When placing bushing in horizontal position allow it to rest on clean padded surface.

Removing Weather Protection—The lower oil end of the larger bushings is stepped between layers and is protected for shipment with tape and gum coating. Do not remove this protection until immediately before installing for service. Do not use knife or scraper but pull downward the projecting loose end of the twine under the tape; this will cut and open the weather protection and facilitate removal. Remove all remaining gum with cloth or waste saturated with warm transformer oil.

Installing Bushings—When installing bushings or removing them from the apparatus do not strike or slide on the edges of opening; cracks and scratches in the varnish coating may permit moisture to enter; bruises and cuts may destroy the bushing entirely.

Fishing Through Transformer Leads—Before installing bushings with tube through condenser, run a wire or a strong string through the tube to pull up the transformer lead at the same time that the bushing is lowered into place. The total length of lead including terminal on its upper end must be such as to give ½" slack to prevent expansion and contraction strains later.

Minimum Oil Level—Unless minimum oil level is marked on condenser, bushings with stepped lower end must have the highest step extend for at least 2" below the minimum oil level. Do not apply voltage with the highest step above the oil level.

Flange Gaskets—The gaskets, used between bushing flange and cover boss, during assembling, should be painted on both sides with a heavy coat of gasket cement.

Bushings With Gaps—Standard bushings of the latest designs are equipped with a gap on the bushing flange. Special and High Altitude bushings have gaps with electrodes pointing in the same direction. The outline drawing of transformer shows the location of the gap electrodes.

Connecting Outside Lead—Connections to the outside end of the bushing should be made so that no stresses will be produced by contraction or expansion of the lead due to heat. A right angle bend a short distance from either end usually prevents this. The length of the lead span to the next support should not be over 15 feet.

Drying Out Bushings—Bushings stored in damp places may absorb some moisture and should not be put into service until dried, unless power factor tests show them to be satisfactory. Bushings may be dried by storing them for several months in a dry place with the temperature at all times slightly higher than ambient temperature. The drying may be accelerated by placing bushing into 80 deg. C. ± 5 deg. C. for not less than two weeks. Even then it is recommended that a power factor test be made to remove all doubts as to whether the bushing is dry.

Caution—Bushings should be mounted only on transformers for which they were ordered. Secure approval or recommendation from factory if it is desired to use them on any other transformer.

MAINTENANCE

Bushing Tests

Power Factor Tests—Many customers find it advisable to make annual Power Factor Tests, and at the same time, make a visual inspection of the mechanical condition of bushings. The Westinghouse Company is not recommending a complete annual check of all bushings, because some customers feel that an annual check is not necessary. However, the fact that the annual check is made by many progressive customers indicates its desirability.

Some of the early bushings do not have the same puncture strength as bushings of later designs. Also in some cases, the lower end of the older types of bushings are shorter than those of later bushings. For these reasons their condition should be checked at shorter intervals than will be required by later designs. Bushings in very important locations where an outage might cause a serious disturbance, should receive annual Power Factor Tests, and semi-annual visual inspection.

I. **Power Factor and Capacitance Tests**—These are made in the field without the removal of the bushing from the apparatus, except in those transformer bushings where the lead is a solid stud, and other transformer bushings where the lead to the winding is not detachable from the cap without removing the bushing.

II. **Visual Inspection**—The bushings should be inspected for leaking compound, mechanical damage, broken away cement, broken or cracked porcelains, accumulations of dirt on porcelain, or carbon on lower end, etc. If any of the above are found and cannot be removed by cleaning, the bushing should be removed from service. Leaking compound even in small amounts is a potential hazard, because moisture may be drawn into the weather casing.

The Westinghouse Company recommends testing all bushings periodically, and the immediate reconditioning or replacing of bushings which the test results may indicate to be below normal. The Company does not have testing sets for sale, although they use them in the factory where bushings, both new and repaired, are tested before shipment. Sets for use in the field for regular testing may be purchased outright from manufacturers of testing equipment. Other sets including the service of operators are available to the industry.

The power factor will indicate the dielectric losses and shows the general condition of the insulation. The capacitance measurement is valuable to show

Condenser Bushings—Continued

INSTRUCTIONS—Continued

if a weakness exists in any layer of the bushing.

For bushings where the fished through lead with top cable connection is used and where it is possible to disconnect the transformer winding from ground, the bushings may be tested without removal from the apparatus providing the testing set is equipped to bring the tube and lead to the same potential and phase relationship If there is a layer of tape on the lead such as is used in present designs and has been used in most of the old designs this will be sufficient insulation to permit of testing the bushing without removal. A thin wall insulating tube slipped down over the lead provides ample insulation for the top end of the lead.

If high losses are found it is best to determine their location before removal of the bushing for they can often be eliminated by cleaning some surfaces.

Power factors are caused to vary by changes in temperature. It is therefore desirable that the tests be made in warm weather with the apparatus not under 60 deg. F. A record of the test should include the temperature of the bushing, as well as the ambient temperature.

The approximate temperature of the bushing may be determined by one of the following methods.

(a) Use the mean of the air and top oil temperature as measured by thermometers. The oil temperature to be measured at the top of and inside of the tank. The air temperature to be measured in the shade, at a point not less than 4 feet away from the tank.

(b) Measure, with a thermometer, the temperature on the outside of the tank at the level of the top of the oil and add 5° to allow for the differential in temperature between that of the bushing and the outside of the tank.

(c) If the apparatus has been out of service for a sufficient time to allow all parts to cool to atmospheric temperature, then the atmospheric temperature (measured in the shade) may be used.

The power factors at which apparatus should be withdrawn from service will of course depend a good deal on the seriousness of an interruption on the particular circuit. A bushing having a power factor measurement within the limits of the curves (See Fig. 2) will have a dielectric strength equivalent to that necessary to meet the standardized one minute acceptance test and will be satisfactory for service.

Additional Tests for Plastic Filled Bushings—To test a plastic filled bushing for moisture in the compound the following checks may be made. These checks will show as low as 0.15% of moisture. (The tests are not applicable to bushings built before 1922 with the hard compound.)

To make the test, the cap is removed to expose the plastic. One end of a red hot ¼" rod is pushed into the plastic. If moisture is present a crackling, sputtering or hissing noise will be heard. If no moisture is present the plastic melts quietly.

Another very effective test is to place some of the plastic on a piece of wire and melt it in the flame of a blow torch. The flame should be turned low so that the amount of noise present will be reduced. If there is moisture a sputtering noise will be heard and small sparks will be thrown off. If the plastic is dry it will melt without disturbance.

When water is found in the plastics the bushing should be taken out of service and reconditioned.

In the spring cap type of bushing, it is not advisable nor necessary to remove the cap. Enough plastic for test may be removed on a small stick or rod inserted through the pipe plug connection on top of the cap.

On the later type of bushings this pipe tap plug is provided so that a pressure test of 15 to 30 pounds with a **dry** air or gas can be applied to test for leaks. A pressure gauge left for at least 15 minutes with line closed after the outside pressure is removed will show definitely if the bushing is tight. The use of oil or soapy water over suspected parts will show large leaks.

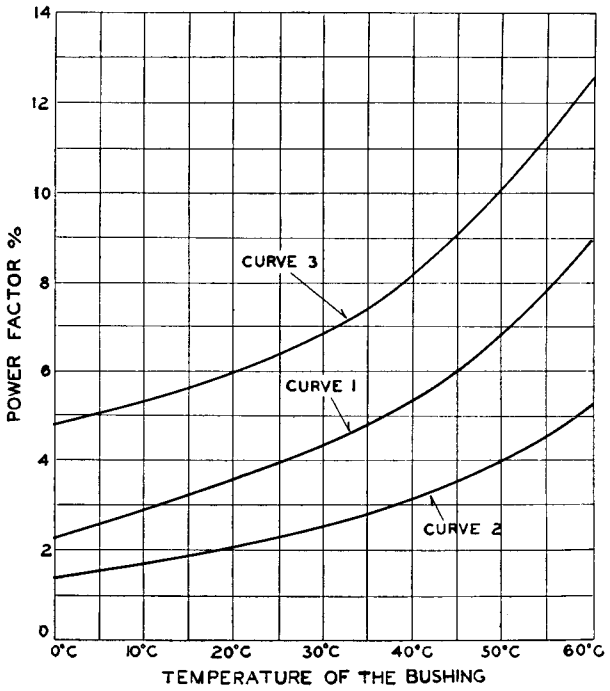

FIG. 2—POWER FACTOR CURVES

Curve 1—For Standard Condenser Bushings on Apparatus whose temperature does not exceed 70°C.

Curve 2—For Standard Condenser Bushings on Apparatus whose Oil Temperature is 70°C. to 85°C.

Curve 3—For Semi-Condenser Bushings.

Note—Tests should be made with the bushing disconnected from all lines. Testing when the bushing is below 15.5°C. is not recommended.

Condenser Bushings—Continued

INSTRUCTIONS—Continued

Additional Tests for Oil Encased Bushings

(1) Check oil level periodically and adjust height by adding a small amount through the plug in the cap when necessary.

(2) Check condition of oil at maintenance periods by making a dielectric test on a sample drawn at the flange. If oil tests below 18 KV on a 1–10″ gap it should be replaced. Be certain the sample is not contaminated by coming in contact with the hands of the operator or with unclean tools.

(3) If the dielectric strength of the oil is found to be low, it is suggested that the cap be tested for tightness. This can be done by testing with dry air at not over 15 pounds pressure. Check for leaks by coating the cap surface with soap lather or with the pressure source removed, hold the pressure for 30 minutes without drop.

RENEWAL PARTS AND REPAIRING

For minor repairs of condenser bushings, such as replacement of flange gaskets, bushing gaps, terminals, etc. replacements parts may be ordered from the Sharon, Pa. Works. Refer to the bushing nameplate data, giving stock order number and drawing or style number when ordering renewal parts.

When a bushing is shown to be damaged or defective by inspection or test, and major repairs or replacement are required, definite recommendations for specific bushings will be given by the factory.

When repair is recommended and customer decides it is the economical procedure for rehabilitation, the bushing should be returned to the factory for repairs. A few advantages obtained by returning the bushing to the factory for repair are as follows:

(1) The proper processes, gasket materials, filling plastic, cements, etc. are used.

(2) Whenever possible the bushings are changed to latest construction and all gaskets are renewed.

(3) Pressure tests are made to insure tightness of the condenser and the weather casing assembly.

(4) Power factor tests and sixty cycle acceptance tests are made. A bushing having a power factor higher than two per cent is rejected. A repaired bushing must withstand the same 60 cycle voltage test as a new bushing of the same design.

(5) Experienced workmen and special facilities are available.

(6) A bushing repaired at the factory carries the same warranties as a new bushing.

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