MEDIUM VOLTAGE FILE

INSTRUCTIONS FOR MAINTENANCE OF SWITCHGEAR INSULATION

IMPORTANCE OF MAINTENANCE

The life and performance of any insulation system is a function of the care and maintenance it receives. It is a well recognized fact that equipment which has moving parts is subject to wear and tear and requires regular maintenance. The necessity for similar care of insulation is often overlooked because insulation is static in nature and quiet in operation. However insulation is subject to continual stress-electrical, mechanical, thermal and chemical. In addition, insulation must perform its function under a wide variety of conditions, many of which can be detrimental unless properly controlled. A program of periodic inspections will reveal the conditions under which a given installation must operate. An appropriate maintenance program can then be developed based on the information thus generated.

ELEMENTS OF A MAINTENANCE PROGRAM

1. Although each installation will have distinctive maintenance requirements certain basic elements will be part of any program.

   1a. Periodic inspections are essential.

   1b. Cleaning and renewal will be part of the program.

   1c. Remedial measures to correct specific problems will be included as required.

2. The importance of a thorough periodic Inspection Procedure cannot be overstressed. A detailed Inspection Procedure is described in a separate write-up, "Inspection of Switchgear Insulation".

3. Clean-up and paint-up may be hackneyed expressions but they are the bulk of a good maintenance program. These procedures constitute Preventative Maintenance, the efforts which forestall development of serious insulation problems.

3a. Blowers or vacuum equipment to remove dirt and dust may be used.

3b. Wiping with lint free cloths, paper towels, or brushing with soft bristle brushes to dislodge dust accummulations is often employed.

3c. The use of mild solvents such as Stoddard"s solvent to loosen more stubborn dirt is recommended.

3d. Demineralized water may be used to wipe off glazed porcelain insulators.

3e. Detergents should not be used.

3f. In addition to cleaning, a renewal of varnish or enamel finishes may be required from time to time.

4. Remedial measures must be undertaken if problems develop. These are usually very specific and functionally oriented.

4a. If such measures are to be permanently effective they must be directed to the causes of the difficulty.

4b. Such measures must also restore each distressed component to its original level of performance.

4c. Each maintenance program must have sufficient flexibility to accommodate whatever measures are indicated by the conditions found in the inspection.

GENERAL REMEDIAL PROCEDURES

1. Physical damage to any part of the insulating system usually requires replacement of the damaged part.

1a. The cause of the damage must be pin-pointed to determine if such damage could possibly recur from a repitition of the same cause.

1b. The damaged parts must be properly identified so that suitable replacements can be obtained.

1c. Repairs to physically damaged parts should normally be considered as temporary measures until suitable replacements can be procured.

1d. Loose or missing mounting hardware must be checked for carefully and appropriate action taken.

2. Heat damaged parts may be restored by painting or varnishing if the damage is superficial. Otherwise replacement is advisable. When paint or varnish is indicated, clean the damaged part, then sand lightly to insure proper adherence of the new coating.

3. Moisture problems may require special procedures.

3a. Physical problems may occur within or external to switchgear structures permitting entry of moisture. These conditions must be corrected. Leaking roofs can often be caulked to block moisture entry. Ventilating openings may require special baffling to block wind-driven rain or snow. It is important to remember that even outdoor switchgear is not normally designed to seal out water completely, but to prevent the entry of water into vital areas. Indoor switchgear is not normally designed to resist external entry of water at all. Each physical problem resulting in moisture penetration must be evaluated on its own basis and appropriate measures specified. Appropriate action may be localized completely outside the switchgear.

3b. Condensation of moisture within a switchgear assembly can be particularly troublesome. A review of such problems and their sources is contained in a separate write-up, "Inspection of Switchgear Insulation". Basic means to prevent condensation are heat and ventilation.

3b1. Pools of water under and near switchgear structures must be eliminated.

3b2. Ventilating openings must be free of any blockage to permit proper circulation of air. This ventilation relies on natural convection so that even minor blockages may inhibit proper air flow. Since a proper ventilating system must have inlets and outlets both must be kept open. Filters when used must be cleaned or replaced regularly.

3b3. The heat generated by losses in bus and risers encourages natural convection. In many indoor and in all outdoor installations heaters are provided to promote air circulation when units are de-energized or lightly loaded. This heat, whether from losses or from heaters, also raises the air temperature within the switchgear at least a few degrees above outside ambient so that even if the incoming air is fully saturated the inside air temperature will be above dew point The importance of heat in controlling condensation must not be overlooked. In a maintenance program it is therefore necessary that steps be taken to be sure that heaters when supplied are working satisfactorily and that they are energized at least during those periods when heat is not being supplied by conductor losses in the switchgear. Switchgear in storage should have heat applied to prevent condensation.

3c. There may be instances when switchgear has been flooded. Should organic insulation be immersed in water for any extended time it should normally be replaced. There may be instances when the importance of restoring electric service may warrant abnormal risks - sufficient time not being available to permit replacements. In such situations

insulating members should be cleaned and the entire switchgear assembly dried out. Auxiliary heat should be applied to raise air temperatures to as high as 55°C for a minimum of 48 hours. Equipment should not then be energized until an appropriate high potential test indicates that performance in service will be satisfactory. Should it be possible to remove affected insulating members from the switchgear and bake them in an oven, temperatures up to 100°C may be used at baking times of about 8 hours. Again high potential tests should be used to determine performance of the insulation before replacing equipment in service. Extrapolations between stated times and temperatures noted above and normal 25°C ambient temperature may be made on the approximate basis that the time of heating will vary inversely with the square of the temperature rise over 25°C.

$$\text{Time} \simeq \frac{1}{(\text{Temp. Rise})^2}$$

4. Corona occurence in switchgear is most infrequent but can be a serious problem should it occur. Since corona is always associated with air gaps, specific measures have been utilized to eliminate or short circuit the affected gaps.

4a. Various means of eliminating air gaps by filling have been tried. The most successful of these methods uses a room temperature vulcanizing silastic material (RTV) as a caulking compound in the affected air gap. (Ref. Dow Corning #RTV 891 - Westinghouse #45793 BW supplied in a flexible tube)

4b. Various conducting or semi-conducting coatings applied to insulating materials adjacent to the affected air gap have been tried in switchgear with inconsistent results. None of these methods can be recommended. Metallic spring conductors to bridge the air gap have been particularly unsuccessful in eliminating corona in switchgear and are not recommended.

5. Tracking on organic insulating materials can occur if all conditions required are satisfied. (See "Inspection of Switchgear Insulation"). Control of tracking is possible by controlling or preventing these conditions.

5a. Eliminate surface contamination by regular cleaning.

5b. Minimize or eliminate moisture on bridging organic insulating members.

5c. Replace susceptible materials with track resisting or non-tracking materials.

5d. Coat susceptible materials with "Limitrac" Paint - Westinghouse #53320 KF. This is a means for extending the resisting time of the underlying material. It does not prevent tracking indefinitely. The Limitrac coating will be eroded by the tracking stresses present at a slower rate than the underlying material. No carbon will be deposited in the erosion process. When used, the "Limitrac" coating must be renewed from time to time to maintain its track resisting quality.

6. Fungus growth in switchgear can occur in tropical and some sub-tropical areas. This is a special problem affecting not only the insulation but other areas in switchgear. Refer to factory if fungus growth is found.

SPECIFIC REMEDIAL MEASURES

1. Bus Bar Sleeving or Tubing

1a. Sleeving exposed to physical cracking or thermal distress should be replaced.

1b. Sleeving which has been exposed to excessive moisture should normally be replaced. If there is no apparent damage otherwise, however it may be possible to satisfactorily dry out the sleeve. Guide lines for drying insulation have been noted previously. Anytime this technique is applied, a high pot test at appropriate levels is strongly recommended before the switchgear is reenergized.

1c. Sleeving which has been slightly abraided or which shows minor erosive damage to the outer finish extending not over .030 inches in depth may be cleaned with lint free cloths or paper towels dipped in Stoddard's solvent. This should be followed by lightly sanding the affected area and covering with one or more coats of a good air drying insulating varnish such as Westinghouse #3210lEW.

1d. Sleeving which has been moderately scarred or eroded may be handled as in 1c above providing the depth of damage after sanding and cleaning is not greater than one-third the thickness of the insulating wall. In addition varnished cambric tape should be applied to the damaged area in at least two layers (two-third lap each layer). Tape so applied should overlap the non-damaged area of the sleeve at least two inches on either side of the damage. The tape should be tapered smoothly toward each end of the overlap. Ends may be secured with three wraps of .015 X .75 friction tape located about one-half inch from each end. A good air-drying insulating varnish should be applied to the sleeve area under the tape so as to be tacky when taping is started and then applied over each layer of

cambric as taping progresses. Varnish must be applied liberally so as to get complete coverage of the sleeve area or tape layer but not so liberally as to run-off or drip. After tie-down, a final coat of red enamel #32230AE should be applied. (Varnish Cambric #41561GH is available in .010X1; .010X1-1/2; or .010X2 inches - Insulating varnish #32101EW). If other than above enamel or varnish are used, a sample should be prepared ahead of time and allowed to dry to determined if the varnish and enamel to be used are compatible. Tape should be applied with a steady even tension in order to produce a firm void-free wrapping.

2. Bus Supports

2a. Bus supports of various types have been supplied over a period years. Each type is distinctive in its characteristics and requires specific consideration.

2a1. Various grades of paper base laminated Micarta.

2a2. Polyester glass supports made with track resisting resin.

2a3. Porcelain supports.

2b. The laminated Micarta and polyester glass supports are supplied in a two piece slotted assembly arranged to hold three phases of insulated bus bars. Each support has been fabricated from a flat molded plate approximately (3/4) to (one) inch in thickness. Mounting holes are disposed so as to fasten the support to the metal structure - at the same time bringing a clamping action to bear on the bus bars.

2c. Porcelain bus supports are formed porcelain plates with single through slots - each support designed to accommodate a single insulated bus bar. Some porcelain supports are provided with holes for securing them to the metal structure in such a manner

that mechanical stresses in the porcelain are minimized. Other types of porcelain support are arranged for mounting in a channel frame which secures them to the metal structure. In multi-phase assemblies for two or more bus bars various means are employed for clamping the required sets of porcelain supports together - again to minimize mechanical stresses in the porcelain. The several means for "soft" mounting or clamping of the porcelain include washers and spacers fabricated from thin sheets (1/16-1/8 thickness) of glass polyester materials. In some cases these spacers project ahead and behind the support in a direction normal to the mounting plane of the support. These projecting fins serve the additional function of increasing air strike distances in the vicinity of the support - thereby adding to the impulse strength of the support assembly. In any operation requiring loosening or displacement of porcelain supports it is essential that all "soft" spacers be restored and that means for clamping the supports be properly tighted and secured if the mechanical and electrical integrity of of the support assembly is to be maintained. The insulated bus bars themselves tend to float somewhat in the porcelain slots.

2d. Bus supports of all types exposed to physical or thermal damage should be replaced unless the damage is found to be superficial.

2e. Bus supports exposed to excessive moisture (except porcelain types) should be replaced. If there is otherwise no apparent damage drying-out operations as previously described may be undertaken . If necessary or convenient, bus supports may be removed for oven heating following the same temperature criteria cited above. With the older type paper laminated Micartas, replacement with track-resisting polyester glass material (Westinghouse #4763 BC) is

recommended for serious consideration. Once again high potential tests before re-energizing the switchgear are essential.

2f. Bus supports with moderate physical scarring or erosion may be cleaned, sanded, and revarnished (similar to bus sleeving above). In considering the revarnishing the varnish used may be Westinghouse #32101 EW or equivalent. This will restore the moisture resisting characteristics of the original "as-molded" surface of laminated Micarta supports. However serious consideration should be given to "Limitrak" coating of the entire surface of laminated micarta type supports to render them track-resistant. (Refer to description of "Limitrak" below) Porcelain supports with superficial surface chips or scratches should be cleaned and varnished with #32101 EW or equivalent to prevent dirt accumulations on the unglazed coarse-surfaced porcelain. Chipped porcelain supports should be closely examined to determine if chipping occurred due to faulty mounting or clamping (as explained above) with appropriate corrections being made as required.

2g. Bus supports which show signs of tracking or corona damage should be reconditioned or replaced. Replacement of laminated Micarta type supports with track resisting polyester glass material #44763 BC is strongly recommended. Porcelain supports, although basically unaffected by tracking, may exhibit tracking signs in contamination layers on their surfaces. A thorough cleaning of the porcelain is all that should normally be required to remove the contamination followed by rinsing with demineralized water.

2h. "Limitrak" coating is identified as Westinghouse #53320 KF. This coating is normally applied to those insulating members bridging phase to phase or phase to ground where tracking can occur. It is used to protect those materials which are susceptible to tracking damage. Where "Limitrak" is applied, it is generally understood that all of the conditions required for tracking can possibly occur. The "Limitrak" coating is composed of a material which slowly erodes in the presence of the tracking stress without leaving a carbonaceous residue. Because its protecting mechanism is a slow erosion process, the amount of protection will vary directly with coating thickness. 20 mils has been established as the thickness which will prolong insulation life sufficiently for most applications. However this thickness can be achieved only through applying multiple layers each 3 to 5 mils thick with appropriate drying time between applications. In many cases of field maintenance, time will not permit the application of the full 20 mil coating. Since the track resisting life of the coating is a function of its thickness, even a single coat 3 to 5 mils thick will increase track resistance appreciably over that of the underlying insulation. "Limitrak" should only be applied to bridging insulation members such as bus supports and circuit breaker bushings where its full functional potential can be realized. "Limitrak" is not recommended for use with track resisting polyester glass materials or with bus sleeving.

3. Taped Joints

3a. Over a period of years there has been a wide variety of taping practices. The particular variety which was applied to any given installation was consistent with test requirements and design

philosophy in use at the time the initial equipment was built. It is therefore recommended that the taping practice called for in the instruction book supplied with the equipment be followed in each instance. As an alternative taping instructions on drawings 508A777, 508A778, and 508A779 may be used.

3b. In general the quality of taping is determined by the care with which it is applied. Tape must be wrapped with good even tension and must properly overlap adjacent insulation. Successive laps and layers must be built up evenly toward the center of the taped area and must be adequately secured. Later practices which use compounds such as "Dux-seal" under the tape yield a more resilient final mass than earlier practices which use only cambric. In a good quality taping job, no matter what practice is used, all spaces under the tape must be filled. No pockets to trap dead air should be permitted. Excessive use of varnish can be as detrimental as too little varnish in establishing the quality of taping.

4. Insulating Compounds

4a. Two general types of insulating compounds have been used in metal clad switchgear.

4a1. A black tar-like substance usually identified as #1001-1 ~~#10001-1~~.

4a2. A red thermo-setting polyester compound.

4b. Compound #1001-1 (Westinghouse #5583lAA) is applied by melting the substance at approximately 100°C and pouring it into black Moldarta boxes clamped around the area to be insulated. Care must be exercised to control the heat used to melt the compound because the flash point temperature and melting temperature are very close together. On cooling, compound #1001-1 shrinks so that further

"topping" pourings are required to properly fill the Moldarta box. Pothead filling compounds should not be used in place of #1001-1 as their melting temperature is usually 10° to 15°C lower that of compound #1001-1 and the pothead compound may melt and leak out in service.

4c. Polyester compounds come in several varieties depending on the application. These compounds are composed of two parts which must be thoroughly mixed before pouring. Polyvinyl chloride jackets are secured and sealed around the area to be insulated. The mixed polyester is poured into the jacket and will gel in several hours. A full jacket must be poured at one time. The polyester cannot be added like a topping after the original pouring has gelled since no bond will be made with the original material. The jacket may be stripped off 24 hours after gelling or it may be left in place if desired. The several varieties of polyester compounds differ from one another in gel time. In some instances polyester compound is poured into a porcelain cavity. A longer gel time compound is normally used in such cases to minimize shrinking.

4d. When a poured compound is to be used it is suggested that the factory be contacted for detailed instructions.

4e. When a compounded joint insulation is to be replaced consideration should be given to using tape per drawings 508A777, 508A778, and 508A779.

5. Primary Receptacles

5a. Primary receptacles ("Bottles") for supporting the stationary portion of the separable primary contact structure have been supplied in several different types of materials.

5a1. Black Moldarta bottles made from high pressure molded phenolic materials, - 5 KV applications only.

5a2. Red polyester or epoxy bottles - 5 KV applications only.

5a3. Glazed porcelain bottles - 5 KV and 15 KV applications.

5b. Over many years bottles have been among the most reliable insulating components. When distress has occurred involving bottles the basic cause has usually originated in an area away from the bottles with bottle breakage or distress being a secondary contingency.

5c. The nature of bottle distress has most often been physical breakage due to mechanical or thermal shock (falling objects, misalligned contacts, flashovers, etc.)

In some cases where faults have occurred in the breaker element, copper vapor has been deposited on bottle surfaces. In all of these situations the bottles must be replaced.

5d. There may be cases found where the as-molded surface of moldarta, polyester glass, or epoxy bottles have been roughed due to contaminants or other environmental conditions. Cleaning, light sanding and varnishing will restore the surface finish to permit ease in cleaning.

6. Circuit Breaker Insulation

6a. The maintenance of circuit breaker insulating members is discussed in some detail in the breaker instruction books and will not be reviewed here.

6b. One particular item which should be noted concerns laminated paper bushings which are components of all but the "Porcelline" breakers. All bushings of this type produced since 1956 have utilized the "Limitrak" finish which has been

described above. It is important to use "Limitrak" should refinishing of these bushings be required. "Limitrak" is also recommended for refinishing older type bushings should this be required.

7. Insulating Boots

7a. Newer switchgear equipment utilizes polyvinal chloride jackets (Boots) around joints in many places on the main bus and risers. These boots are of a split design slipped over the joint and bolted together with insulated hardware.

7b. Boots may be removed easily for access to the joint and then remounted as required. Always use insulating hardware furnished with the boots.

In summarizing these guide lines for insulation maintenance it is of prime importance to reiterate the necessity of a well-planned maintenance program to guarantee reliable performance. No simple statement is really adequate to cover all of the facets and ramifications of this subject. However, two brief statements establish the key to good insulation maintenance - Keep it Dry!! - Keep it Clean!!