SALVAGING FLOOD DAMAGED ELECTRICAL EQUIPMENT

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Overview

In all drying out of electrical windings, the regulation of temperature should be controlled carefully. Maximum drying temperatures on windings should not exceed 194ºF (90ºC) as measured by thermometer. This will prevent not only the rapid thermal deterioration of the insulation but damage from the high vapor pressures that would be obtained if steam were produced.

Several methods are available for drying equipment. Probably the most satisfactory solution to the problem is when the windings can be placed in an oven with suitable temperature control and proper air circulation. Banks of infrared lamps may be used when this is not possible, or a suitable housing may be built around the machine, using steam coils or electric resistance type units for a source of heat. Openings should be provided for the free circulation of air. Blowers may be used to increase the air movement. Vacuum drying has also been effectively used to expedite the return of equipment to service. Certain precautions are necessary if this method is used, and it should be carried out only by experienced personnel.

Another method often used is to circulate low-voltage current through the windings. This should not be done, however, until the insulation resistance has reached a value of at least 100,000 ohms. Look for Megger® Insulation Testers that have kilohm ranges in order to perform this check prior to application of current. These models include the MIT400 Series and MIT320 & 330. Measurement is performed at only 5 V, so will not damage even the worst of insulation. Welding sets may be used to provide the current. The flow should be limited to only a fraction of nameplate amperes, and a careful check must be maintained on maximum temperatures on the insulated parts.

On ac generators, drying current may be provided by driving the units at less than rated speed with the terminals short-circuited and excited with very low values of field current. Here again, this should be done only by those with experience in such methods.

During drying operations, when insulation resistance values are used as an indicator of the suitability of windings for service or for application of test potential, the drying must be continued for a sufficient time to make sure that the values are reliable. Often the resistance curve will take one or more sharp dips before leveling off or continuing to increase in a positive direction. This is due to moisture working out of the windings. When the machine is completely dried out, further work is required to remove any remaining dust. This may be done through the use of dry compressed air at pressure not exceeding 40 psi.

With respect to particular classes of electrical equipment damaged by flooding, the procedures listed below should be followed.

Rotating Electrical Machines

1. Completely dismantle all parts.

2. To remove silt or dirt, wash all parts of the machine — except ball or roller bearings, but including windings — with clean, fresh water or stem clean them. Follow this with a thorough cleaning, using a suitable grease solvent. Many such cleaners are toxic, and the necessary safety precautions should be taken.
3. Thoroughly clean all bearings and housings, paying particular attention to oil grooves and oil reservoirs, which may collect silt and dirt. Disconnect and swab any oil lines, or stem clean and dry them.
4. Dismantle brush rigging and clean insulators. Some insulators will retain water, and must be dried thoroughly.
5. Do not apply any voltage to a winding until an insulation resistance reading of at least 100,000 ohms is obtained for several hours, and then only a very low voltage should be used. If windings are very wet, even the low voltage of hand-cranked ohmmeters can puncture the insulation. To avoid this, the crank should be turned at low speeds until some knowledge of insulation resistance value is obtained. Modern microelectronic testers have voltage regulation that eliminates this problem. As mentioned above, models with kilohm ranges at low voltage (MIT400 Series and MIT320 & 330) are ideal. The motor can first be checked at low voltage to be assured that it meets the 100-kohm requirement, and then the effectiveness of the drying process can be monitored until resistance has increased into the megohm range.
6. Commutators can be difficult to dry out. It may be necessary to loosen or even remove some of the V-ring bolts or clamping nuts in order to let the water out from the inside of the commutator. On large commutators it may be necessary to increase the drying temperature to as high as 266ºF (130ºC) if lower temperatures do not produce satisfactory results after a reasonable period.
7. Bands on armatures or rotors should be checked carefully for tightness. For some applications, they will have to be replaced because of looseness resulting from drying out of insulation underneath.
8. Some slot wedge materials will be affected by moisture. All wedges should be carefully examined and new wedges installed where necessary.
9. DC motor or generator field coils and field coils from synchronous machines sometimes present problems. It may be necessary to remove these coils from the machines for proper treatment if it is found that it is impossible to bring up the insulation resistance otherwise. After a thorough drying in a suitable oven, they should be immersed completely in insulating varnish while hot, and allowed to cool while still immersed. This will tend to draw the varnish into the inside layers. When cooled, the coils should be checked for short circuits by making a comparative test of their resistance. A Megger DLRO10 digital low resistance ohmmeter will indicate open coils, and can also be used to determine shorted turns by the reduction in resistance that turn-to-turn shorts produce.
10. After a thorough cleaning and drying, most windings should be treated with insulating varnish, particularly if cleaning solvents have removed any of the varnish coatings. Dipping and baking-type varnish, followed by a suitable baking period, is

preferable, but air-drying varnish may be used to expedite the return of equipment to service; this latter type is only recommended if the original varnish is in reasonably good condition.

11. Before any machine is started, check the entire installation, paying particular attention to lubrication and electrical connections. Determine that no tools or materials have been left in or on the machine. Three-phase motors being restored to service can have proper connection assured for correct rotation with the Biddle® Motor and Phase Rotation Tester (560060). This model will check correct phase rotation for both motor and live line, while 3-phase lines can be separately checked with a Phase Sequence Indicator (565250). When put back into service, rotational speed of motors can be readily checked with contact and photoelectric hand tachometers. These handy instruments are particularly useful as flooding may have made digital on-line indicators inoperative. For routine electrical checks, remember that Megger offers a full line of hand-held and clamp-on multimeters.

Switchboards and Electrical Controls

1. Thoroughly clean and dry out all control equipment, dismantling where necessary. Operating coils should be thoroughly dried and dipped in insulating varnish and baked or given one or more coats of air-drying insulating varnish. Check all contacts. Be sure moving parts operate freely.

2. Oil pans on starters and oil switches must be cleaned, dried out, and refilled with oil of proper dielectric strength. Insulating oil can be tested in full conformance to ASTM standards with the Megger OTS60PB and OTS60SX Oil Test Sets. Insulating barriers should be dried out or replaced if badly warped.

3. Meters and relays usually will have to be reconditioned at either the manufacturer's service shop or factory. In many instances, it will be cheaper to replace them.

4. All bus insulators and control wiring on switchboards should be cleaned and dried thoroughly. Normally, an insulation resistance of at least one megohm per 1,000 volts operating potential, with a minimum of one megohm, should be obtained before energizing. This is a very basic and universal insulation requirement, and can be performed with any Megger Insulation Tester. Specific models should be further evaluated for additional features and functions against additional demands and operator’s preferences, as well as budget constraints. Standby batteries should be checked for their readiness to come on line using the BITE family of Battery Impedance Testers (BITE2, 2P, & 3). Battery straps can be checked for corrosion or excessive resistance with the DLRO10.

Transformers

1. Remove covers or inspection cover plates. Note the condition of the oil and windings, and check for signs of failure. Many transformers are oil insulated, and flooding may have introduced contaminants, including water, that will reduce dielectric strength and deteriorate performance. This can be tested with Megger Oil Test Sets as mentioned above. Inspect all connections for looseness or indications of heating. Draw oil samples from top and bottom. Breakdown strength should be at least 22 kV

(25 kV if an askarel such as Inerteen, Pyranol, or Chlorextol is used). Megger test sets test to 60 kV.

2. Check the insulation resistance. The value should be at least one megohm for each 1,000 volts rating, with a minimum of one megohm. Since these measurements are being performed from the “bottom up”, so to speak, any Megger Insulation Tester will do to assure basic performance. But two additional conditions should be noted. It may be preferable to restore equipment to full pre-flood condition, and not just basic operating capability. Especially if maintenance records have been kept (and not lost in the flood), it would be desirable to have a tester that can measure values all the way to those of pre-flood records or condition. This would be best served by a model with extended range, such as the MIT400 Series, MIT510/2 or MIT520/2. Also, for equipment rated at higher voltages, a 5 kV tester should be employed in order to apply the higher voltage stresses that such equipment will experience in operation. Note the condition of bushings, external connections, operating switches, and protective devices. Clean externally and paint the tank if necessary.

3. If water has entered the tank, remove its cover. Flush the windings and core with clean, moisture-free insulating oil. If the transformer is small, remove the coil and core, and dry in an oven at a temperature not over 194ºF (90ºC). Dip and bake the windings whenever the need is clearly evident. Larger units may be dried in the tanks: by forcing hot, dry air at not over 194ºF (90ºC) in and around the windings after the oil has been removed from the tank; by short-circuiting one winding and energizing the other with low ac voltage; or by a combination of these two methods. Insulation resistance checks will determine the progress of drying. A curve should be plotted, showing resistance against time, as mentioned previously. It is best to start at the 5 V level of the kilohm range, then test periodically throughout the drying process. The effectiveness of the drying procedure will be noted by the steady rise in insulation values. If mechanical damage has been done, such as pinholes or burn tracks, the insulation will not spontaneously regenerate, and the drying process can be discontinued without costly expenditure of time, in favor of rewinding or similar repair actions. If the drying operation does proceed successfully, it can be monitored into the megohm range, and then higher voltage tests can be applied without damage until the final desired value is reached. Once the drying process has restored insulation resistance to acceptable values, full performance can be further verified by performing a turns ratio test with the Megger TTR20. Damage to insulation can produce turn-to-turn shorts that effectively alter the turns ratio between primary and secondary windings. The TTR is the most precise and sensitive means of determining the existence and extent of such problems.

4. The oil should be filtered to standard test value of not less than 22 kV, or a new supply of oil of high dielectric strength should be used.

The above procedures also may be used with askarel-filled transformers, but with the following precautions. Oil should not be used as a substitute for any askarel-insulating fluid. Where dipping and baking, or re-insulating is necessary, the manufacturer should be consulted regarding proper materials and procedure. The askarel should be reconditioned, making standard IEEE tests until breakdown values reach not less than 25 kV, or replaced with new askarel.

Cables and Wiring

- All open wiring, including nonmetallic, sheathed cable, can be retained generally after thoroughly drying both cable and junction boxes and remaking connections.
- Armored cable usually will have to be replaced, as will lead cable if the ends have been under water. Salt water is particularly damaging.
- Rubber-covered cable in rigid conduit or in electrical metallic tubing may sometimes be reused, but it must be pulled out of the conduit or tubing in order to clean the conduit or tubing. Care must be exercised in this operation, as the cable insulation may be easily damaged. The conduit or tubing must be thoroughly cleaned of all silt and moisture prior to being used again.
- Potheads and all insulators should be cleaned and carefully inspected for cracks or other damage.

Megger Insulation Testers are the ideal instruments for testing wire and cable for waterlogged condition, opens and shorts. If basic function proofing is all that is required, the MIT320 and 330 are all that is needed to perform all the fundamental checks associated with this application. For more detailed troubleshooting by skilled professionals, the MIT400 Series is preferable. And for higher rated equipment, the MIT510/2 or MIT520/2. Also, don’t overlook storage and downloading capabilities, available in the MIT420, MIT430, MIT481, MIT485, MIT330, and the MIT520/2. For interfacing with insurance representatives, government regulatory agencies, and various third-party involvements, this function is invaluable in proving not only that tests have been done, but that they’ve been done correctly.

Electrical Tools

Electrical tools can be reconditioned in the same general manner as described above. But to put them safely into the hands of employees, and to meet OSHA requirements, final proof can be done with a Biddle Tool & Appliance Tester (235303). Remember that in this application, the reconditioning of equipment for restoration to service, the AC high-pot function would be appropriate.

Finally, don’t overlook the DETEX line of Voltage Detectors and Phasing Testers for employee safety. Under the chaotic conditions of a post-flood situation, power lines may or may not be live. The most reliable way to determine if conditions are safe to proceed with maintenance and restoration is to test first with a DETEX indicator.