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HOW TO RECONDITION

WATER-DAMAGED CENTRAL OFFICE EQUIPMENT

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1. GENERAL INFORMATION

1.01 This Practice contains the procedures recommended for recovering water-damaged equipment, including the power plant, in a central office. Other Practices contain detailed procedures for the disassembly, adjustment and/or assembly of individual apparatus.

1.02 This practice is issued to:

(1) Change Practice to a Bellcore format;

(2) Expand information for electronic type offices;

(3) Refer to new contact cleaning procedures; and

(4) Remove references to panel systems and PBX equipment.

1.03 Any changes or corrections to improve this Practice should be requested in accordance with Practice BR 000-010-015.

1.04 All documents mentioned in this Practice may be ordered through your company documentation coordinator.

Who Is Involved

1.05 Personnel who participate in remedial, reconditioning and restoration work on building, central office equipment and power plants should be familiar with the information that follows.

Common Causes of Water Damage

1.06 Water damage to building and central office equipment may result from a variety of causes. Common causes are:

- Flooding;
- Fire-fighting efforts;
- Defective plumbing; and
- Rain or snow entering windows, ventilators or openings in buildings.

1.07 The importance of thorough planning **before** a water damage emergency occurs cannot be overemphasized. Planning and organization procedures, as presented in Practice BR 010-120-010, can substantially reduce the time required to restore service. Practice BR 010-120-010 also outlines a plan for abandoning a central office in a rising water emergency.

2. REMEDIAL MEASURES AFTER WATER DAMAGE TO CENTRAL OFFICE EQUIPMENT

General Information

2.01 Water damage to central office equipment can vary from a major flood that affects an entire office to roof leaks or broken water pipes, affecting one or more frames. The leaks and breaks and similar incidents, while usually less damaging, occur far more frequently and can be troublesome.

Water-damaged central office equipment and wiring usually can be reconditioned and reused **without** increased maintenance **if**:

- Electrolytic corrosion did not occur to any appreciable extent.
- Equipment is promptly flushed with clean water.
- Equipment is thoroughly dried out, cleaned, and its wiring resistance checked with a meter before battery potential is again applied.
- Drying solvents or agents are avoided.

2.02 The decision whether to replace equipment because of serious electrolytic corrosion must be based on a subjective evaluation of the equipment's condition. No electrical measurements or operational tests should be attempted at this time. The criteria to be used in the evaluation are entirely visual, subject to individual judgment, and difficult to define. External evidence should serve as a guide in predicting the seriousness of the internal damage to relay and magnet coils and various insulation materials.

The following list is provided to help individuals decide whether damage warrants replacing the equipment, or whether the existing equipment can be restored and placed back in service.

- It is important to distinguish between electrolytic corrosion and non-electrolytic or chemical corrosion, which is relatively harmless. Commonly used nickel-silver and brass contact springs usually are unaffected by electrolytic corrosion when briefly exposed to water, if all operating potentials are removed.

  However, zinc-coated parts, such as switch castings and mounting plates, are relatively susceptible to electrolytic corrosion. As a result, nickel-silver and brass springs provide the best indication of electrolytic corrosion. If concentrated bluish-green deposits appear on these metals (particularly at spring pile-ups) electrolytic corrosion is probable. Non-electrolytic corrosion deposits are often more uniformly distributed over larger areas than electrolytic corrosion deposits. These less harmful deposits should be removed from the equipment before it is restored to service to prevent contact contamination wherever possible.

- Severity of electrolytic corrosion varies with (1) the length of time that the equipment potential remains on during the flooding, or later, if the potential is applied again while the equipment is still damp; and (2) the amounts and kinds of salts in the water that can form electrolyte. Therefore, whenever possible, equipment potentials should be removed before flooding occurs. To distinguish between electrolytic corrosion and non-electrolytic corrosion, it is important to know whether the equipment potential remained on during flooding and, if so, for exactly how long.

- Equipment with electrolytic corrosion often can be restored by dry brushing the corrosion products away **if the corrosion is not too severe.** (When dry brushing the corrosion, take care not to brush the debris into equipment nearby). The equipment usually can be reconditioned without danger of excessive relay and magnet coil open circuit conditions or insulation failures. However, where concentrated corrosion products are observed, as on nickel-silver and/or brass springs, or where spring metals or wires have begun to erode, the reconditioning stage has passed and the affected equipment must be replaced.

- Personnel without previous flood experience must resist a temptation to replace flooded equipment by judging it solely on the basis of its appearance after the flood water first recedes. Debris such as mud and silt, and general disorder, are **not** the damage criteria on which the replacement—restoration decision should be based. First, the debris must be removed; then, the true condition of the equipment can be established. The basis for decision is the degree of electrolytic corrosion that has occurred. The reconditioning of equipment that should have been replaced brings about the eventual piecemeal replacement of components, such as relays and magnet coils.

- When qualified appraisers cannot reach flooded offices quickly to decide whether reconditioning is an acceptable risk, the local operations supervisor must decide upon immediate steps. It should be easy to tell if there is no electrolytic corrosion, or if there is and it is severe. If there is no electrolytic corrosion, restoration procedures covered in the following reconditioning plans should be started at once. If electrolytic corrosion is severe, "housekeeping" should be done to prepare for replacement of the damaged equipment. When there is reasonable doubt about the degree of damage, the local supervisor should contact line or staff people and seek advice. In marginal cases, however, it may be advisable to minimize outage time by starting restoration procedures without waiting for an appraisal. The advantage of such action becomes apparent when water damage proves to be minor.

  Frequently it is helpful to remove samples of components from the frames for laboratory measurements and/or studies to judge the extent of the damage. Samples may be sent for analysis to the District Manager — Environmental and Contaminants Research, Bell Communications Research, Navesink Research and Engineering Center, Room 3Z207, 331 Newman Springs Road, Red Bank, New Jersey 07701 [(201)758-3093].

2.03 Equipment sometimes cannot be inspected and cleaned before it must be placed back in service. Because of road or other conditions, cases have occurred where access to water-damaged offices was impossible for extended periods, and the equipment was quite thoroughly dried out by the time attention could be given to it. To quickly restore service, in some cases, the equipment was not flushed off with water; instead, it was "dry cleaned" by brushes and vacuum cleaners. This procedure involves a calculated risk. It is impossible with dry-cleaning techniques to completely remove all the fine binding clay deposits that adhere to water-damaged equipment. These deposits may contain salts that will, after equipment is reenergized, permit electrolytic corrosion or electrical leakage to occur during high humidity periods. Therefore, it appears prudent to make follow-up visual inspections of such equipment at intervals during high humidity periods for evidence of electrolytic corrosion. Inspections should be supplemented by insulation resistance measurements to help detect increased electrical leakage.

2.04 Equipment components sometimes cannot be used after water damage. Some components cannot be dried to give satisfactory operation, and some may be permanently damaged by water. In this latter category are components enclosed in a permanent can cover that is not hermetically sealed, such as 293A reed relay packs, 120-repeat coils, the plug-in base of 275- and 276-type sealed mercury relays, 280-type relays and 177B networks. The black outside coating of cold cathode tubes used in timing circuits is also destroyed by water, making the tubes sensitive to light. Water may swell and permanently damage resistance coils in step switches; tubular capacitors are frequently damaged by water.

2.05 The preceding paragraphs present criteria to use in assessing damage done by water to central office equipment. Equipment not seriously damaged should be reconditioned and placed back in service as quickly as possible. If, for extended periods, the equipment is not accessible to permit damage assessment, supplementary inspections should be scheduled after the equipment is restored to service. Equipment components that become permanently damaged after even brief exposure to water should be replaced immediately.

2.06 Office records, if destroyed, may be reconstructed by consulting the various headquarters records and, if available, the appropriate microfilms.

Reconditioning Water-Damaged Central Office Equipment

2.07 Tables A and B contain the step-by-step procedures of two general plans recommended for prompt reconditioning of central office equipment that was not seriously affected by electrolytic corrosion. These plans have proved effective in past emergencies. Perform the tasks in the sequence they are given. The paragraphs referred to contain detailed instructions on how to carry out each action.

Reconditioning Electromechanical Equipment Damaged by Flood Water

2.08 As water recedes or is pumped from the building, a **clean** water distribution system should be set up according to the individual office plan outlined in Practice BR 010-120-010. **Plenty of clean water must be available for this operation.**

Flushing Procedure

2.09 **Flushing should be started as soon as possible** for two reasons: (1) to rid the equipment of mud while mud remains in a semi-fluid state and (2) to remove absorbed salts from insulation material. If mud cannot be removed promptly, it should be kept wet with water until it can be removed. **Once particles of mud begin to dry out, they become very hard.**

The steps of the flushing procedure are:

(1) Using a garden hose with an ordinary adjustable nozzle, adjust the nozzle for a spray angle of about 45 degrees, spread from the end of the nozzle. (Force of the water spray should not be any stronger than is required to remove the silt and other debris).

(2) Remove the equipment covers and begin flushing at the high water mark and work downward. Do not dampen equipment that was not subjected to water damage.

(3) Start flushing down the back side of the equipment. Then flush down the front side.

(4) Flush in a precise manner; that is, wash down the equipment one relay at a time.

(5) Inspect the equipment for any remaining silt and debris, and flush the equipment down again if necessary. After the equipment is once soaked, flushing it again can do no further harm.

2.10 It is desirable to remove dismountable equipment, such as step switches or plug-in units, from the frames for individual flushing, cleaning and drying. Tag the equipment to facilitate returning it to the location from which it was removed.

CAUTION: Use of commercial rust inhibitors on electromechanical switching equipment is not recommended because gummy deposits may be left on relay parts, such as backstops, and may interfere with operation.

2.11 While the equipment is being flushed, the equipment room floor should be cleaned and mopped. Mopping may be required on a continuous basis during restoration.

2.12 After flushing of cloth-covered cables is completed, open the sewn cable forms. Openings should extend as far up the cables as the wetness appears, or a foot above the high water level, whichever is greater. (During one emergency, vertical runs of new plastic-covered switchboard cables were dried without being split open. Instead, a small slit was cut into the cable sheath about a foot above the high water line. The small nozzle of an air compressor was inserted into the slit, and the moisture was blown out through the lower end of the cable).

TABLE A

HOW TO RECONDITION WATER-DAMAGED
CENTRAL OFFICE ELECTROMECHANICAL EQUIPMENT

Task	Action	See Paragraph
1	Flush mud and debris from equipment with clean water aided by brushing. (Flushing of equipment damaged by water leaks generally should be avoided).	2.08-2.09
2	Clean and mop the equipment room floor while equipment is being flushed.	2.11
3	Drive surface moisture from the equipment with compressed air.	2.13
4	Dry the equipment, using warm air and fans to prevent hot spots.	2.14-2.28
5	Clean electrical contacts and contact surfaces of equipment.	2.36-2.37 2.40
6	Lubricate mechanical equipment where necessary.	2.34
7	Replace equipment that cannot be restored.	2.04
8	Make operational tests. Check equipment for excess electrical leakage before energizing. (Energizing equipment while partially wet usually causes electrolytic corrosion).	2.31-2.32
9	Reenergize equipment and place in service.	2.41
10	Pressure-clean equipment to remove residual silt and debris (if required).	2.39
11	Make periodic inspections for a reasonable period after the equipment has been restored.	2.42

TABLE B

HOW TO RECONDITION WATER-DAMAGED
CENTRAL OFFICE SOLID STATE ELECTRONIC EQUIPMENT

Task	Action	See Paragraph
1	Flush mud and debris from equipment with clean water aided by brushing. (Flushing of equipment damaged by water leaks generally should be avoided).	2.08-2.09
2	Clean and mop the equipment room floor while equipment is being flushed.	2.11
3	Dry the equipment using warm air and fans to prevent hot spots.	2.15-2.28
4	Clean electrical contacts and contact surfaces.	2.51-2.54
5	Replace equipment that cannot be restored.	2.04
6	Make operational tests.	2.31-2.32
7	Reenergize equipment and place in service.	2.41
8	Make periodic inspections for a reasonable period after the equipment has been restored.	2.42

2.13 Immediately after flushing is completed, remove any remaining surface moisture by use of air compressor sets. If contractor air compressors are used, filter the air. (This is done because of the large amount of oil that may be found in contractor air compressors). Water removal can be started on higher equipment, while the lower equipment is still being flushed. It may be necessary to use dry cleaning cloths to remove some of the moisture. Preferably, these cleaning items should be of the type commonly used in central offices (for example, CK-2423 cleaning cloth and CK-14514 compressor set or equivalent). Start removing water at the high water mark and work downward.

Drying Procedure

2.14 Prepare a priority list of the items of equipment to be dried, in order of importance:

(1) Power and tone supplies.

(2) Alarm and interrupter frames.

(3) Test frames.

(4) Markers.

(5) Registers.

(6) AMA equipment.

(7) Connectors.

Note: Items such as senders and trunks can be **dried last,** to be available in sufficient quantities to provide basic service.

2.15 While some equipment may be dried sufficiently to be usable in a day or so, other equipment may require a much longer drying period. Older types of insulation, such as the fiber in pile-ups on "U" type flat spring relays, may be very slow to dry. (Use of proprietary drying, water-displacing or anti-moisture treatments does not help). Items of equipment with crossbar switches and wire spring relays, however, dry quickly and may be safely energized sooner.

2.16 Apparatus and wiring forms dry faster when opened to allow free circulation of air.

2.17 Drying of damp equipment may be accelerated by evaporating moisture into the air and then exhausting the air from the building. The ability of air to carry moisture is increased by raising its temperature. To maintain optimum absorptive capacity of the air during the drying operation, air temperature should be raised to the highest level consistent with personnel safety. Regardless of the temperature, the movement of air through the office should be controlled to hold the relative humidity below 50 percent. (During early restoration stages, it is unlikely that the temperature will have to be raised to very high levels to keep the relative humidity below 50 percent. During later stages, it may be necessary to permit the relative humidity to somewhat exceed 50 percent to hold the temperature to a bearable level).

2.18 Relative humidity should be monitored with a psychrometer near the center of the room. Inexpensive psychrometers using hair elements are satisfactory for measuring the relative humidity. Use a model accurate within a maximum error of 5 percent and an average error of 2-1/2 percent, if possible.

2.19 If power is not available and the outside humidity is appreciably lower (at least 20 percent) than the inside humidity, it is advisable to open the windows and get the air moving through the building. If power is available, the relative humidity may be controlled and the equipment may be dried using one, or a combination, of the following methods:

(1) Use the office air conditioning, if it's undamaged.

(2) Use the office heating and ventilating equipment, if it's undamaged.

(3) Use fans to circulate air through the building.

(4) Use portable sources of heat as described in paragraph 2.21.

2.20 Use thermometers with scales exceeding 120°F to monitor equipment temperatures during restoration work.

2.21 Several portable sources of heat are suitable for drying damp equipment. The best sources are 250-watt, infrared heat lamps, equipped with swivel or clamp-on type sockets that may be fastened to office frames or racks made to hold them. When using these lamps, care must be taken to prevent overheating components.

Another source of heat is the family of commercial heaters. A good heat source for spot drying is a hand-operated hair dryer. Portable home hair dryers with plastic head bonnets and flexible hoses may be preferable because they do not require constant holding. A portable blower equipped with a heat nozzle may prove better than hair dryers for spot drying. Ventilating heaters, the types used by construction workers to ventilate manholes, may be placed at the base of the equipment and the heated airstream directed upward. Salamander type heaters use an open flame and should be used only as a last resort. **Never use salamander type heaters around electronic or switching equipment (because of the large amount of soot from their flame).**

2.22 An attendant should be present at all times during the drying operation to be sure that equipment does not overheat. Electric fans may be used, if needed, to assure proper distribution of warm air to prevent hot spots. If portable propane space heaters must be used, use fans to distribute the heat, and open doors and windows to provide adequate ventilation. **Be aware of the fire hazards associated with using propane space heaters. For example, solvents or aerosol sprays should not be used near open flame heaters or dryers.**

2.23 Telephone switching equipment generally should not be subjected to temperatures above 120°F for more than 72 consecutive hours. For environmental specifications, refer to AT&T Practices 760-555-151 and 800-610-164, and to Bellcore TR-EOP-000 063.

2.24 Two 60-volt arc welding sets connected in series may be used to energize equipment such as heat lamps and emergency lighting facilities. It may be necessary to connect several welding sets to carry the load. A great deal of generating capacity is required to energize the heating devices used in restoration work. Portable or trailer-mounted engine alternators usually are used for this purpose.

2.25 Approved fire extinguishers should be kept nearby, and fire detection systems should be tested and made operable for use during drying operations.

2.26 **Do not use any desiccants. Desiccants are not useful in drying water-damaged central office equipment** because the relatively limited absorption capacity of these materials necessitates use of very large quantities. Further, use of desiccants may cause a contact contamination problem.

2.27 **Do not use aerosol dryers** because they may contain chemicals that will damage the equipment. The use of contact cleaner is **not** recommended.

2.28 Commercial dehumidifiers are not recommended during restoration work because of their limited capacity to remove water, but they may be used to remove residual moisture after restoration.

Use of CK-22659 Water Displacer

2.29 **Do not try to use spray cleaners to remove corrosion products and other water residues.** These residues are not soluble. Spray cleaners can cause moisture to condense on the equipment, resulting in electrical leakage and further damage.

2.30 CK-22659 Water Displacer (lubricant) is designed to displace thick films of water on structural surfaces, power equipment, and other items of equipment where a lubricating film residue is desired or is not objectionable. This lubricant is soluble in CK-19578-L1 trichloroethane. Generally, it should not be used on telecommunication equipment having relays and other components with operating contacts. If the lubricant is applied to such items in an extreme situation, the oil should be removed after the equipment is dry by flushing with CK-19578-L1 trichloroethane. Use blotting paper to catch the drippings that occur while the oil is being removed.

Insulation Resistance Requirements and Measurements

2.31 The net normal insulation resistance on a connection through a central office is about 15 megohms. **Equipment and cabling, however, generally will function satisfactorily without damage after the drying operation has raised the insulation resistance to 3 megohms or more.** This resistance level assumes the absence of abnormal conditions such as silver migration and degradation of rubber insulation. Insulation resistance measurements should be made frequently on water-damaged equipment, and these measurements should be compared to measurements made on identical dry equipment. Comparison of these measurements is useful to check the drying rate and to determine when the damaged equipment may be returned to service. See Figures 1 and 2 for examples of insulation resistance measurement methods.

2.32 Insulation resistance may be measured by using the CK-20538 Volt-Ohm-Milliammeter (VOM) or equivalent, Wheatstone Bridge, or other cable testing equipment. Use automatic line insulation test frames where available.

Operations After Drying

2.33 Corrosion products lower insulation resistance when humidity is present. They should be removed. If left on the equipment, the corrosion products become dislodged and cause contact contamination and other troublesome conditions. A stiff brush is effective for removing corrosion products, used with a vacuum cleaner. Nylon bristle brushes of various sizes, toothbrushes, and teletypewriter cleaning brushes are all effective.

2.34 Equipment should be relubricated in accordance with the appropriate practices. Relay and other contacts should be cleaned if inspection or operational tests disclose contamination.

2.35 The following procedure may help conserve 35- and 70-type fuses. When testing 48-volt circuits, place 150-watt 120-volt lamps, instead of fuses, across fuse terminals. If the supply circuit is grounded, the lamp will glow. Weatherproof "pig-tail" type lamp sockets are convenient to use for this test purpose. Similarly, 13-type resistance lamps may be used for preliminary testing of ringing supply circuits before the fuses are inserted.

2.36 Step-by-step banks should be cleaned. All deposits between terminals must be removed; otherwise, the gritty particles remaining can cause excessive wiper and terminal wear. Use a suitable stiff brush and vacuum cleaner. For procedures on cleaning and reconditioning of step-by-step equipment, refer to the 069 division of AT&T Practices.

2.37 Crossbar switches and relay apparatus should be cleaned and reconditioned in accordance with procedures in the 069 division of AT&T Practices.

2.38 Alarm circuits should be checked and any troubles that are found should be cleared. Operational tests of alarm circuits and associated equipment should be made before the equipment is placed in service.

2.39 All equipment and forms should be pressure-cleaned with compressed air, as required, after the office is working again. If contractor air compressors are used, the air should be filtered because of the large amount of oil normally found in contractor air compressors. **Do not** use compressed air for cleaning solid state equipment. Follow the procedures in the appropriate Practices covering pressure cleaning of the various types of equipment. Refer to AT&T Practice 069-305-301.

2.40 Avoid individual contact cleaning programs unless there are definite indications that dirty contacts are a problem. When cleaning contacts, refer to AT&T Practice 069-306-801. Do not use burnishers or files on contacts.

2.41 Reenergizing the equipment requires the same order of priority as applies for drying equipment. Choose small segments of equipment that show 3 megohms or more of insulation resistance. If fuses open, continue drying and take sample insulation resistance measurements. Use the schematic diagrams to isolate and eliminate those failures that cannot be cleared with normal cleaning and drying techniques.

2.42 Maintenance engineering and operations people who are familiar with the equipment's preflood performance characteristics should make several inspections of the water-damaged central office equipment after that equipment is restored to service. A review of office performance records collected before an inspection often will disclose items warranting close scrutiny. Inspections should be performed quite frequently, possibly at two-week intervals, beginning when equipment is restored. Later these inspections may become less frequent, and perhaps they may be eliminated after six months. Following these procedures should ensure detection of any abnormal conditions that may develop; for example, shortened wiper life resulting when residual silt is not removed from step-by-step banks.

Reconditioning Electromechanical Equipment Damaged by Water Leaks

2.43 In situations where equipment is damaged by water from a broken pipe, roof leak or dripping condensation, flushing with water should be avoided. Remove power from the frame, cover the equipment with a suitable tarp or plastic sheet, and dry the equipment quickly as possible. Drying procedures and restoration methods are covered in paragraphs 2.14 through 2.42.

Reconditioning Solid State Electronic Equipment Damaged by Flood Water

2.44 Table B presents a plan for reconditioning water-damaged solid state electronic equipment.

CAUTION: Do not use compressed air for cleaning or drying. (Refer to AT&T Practice 069-305-301).

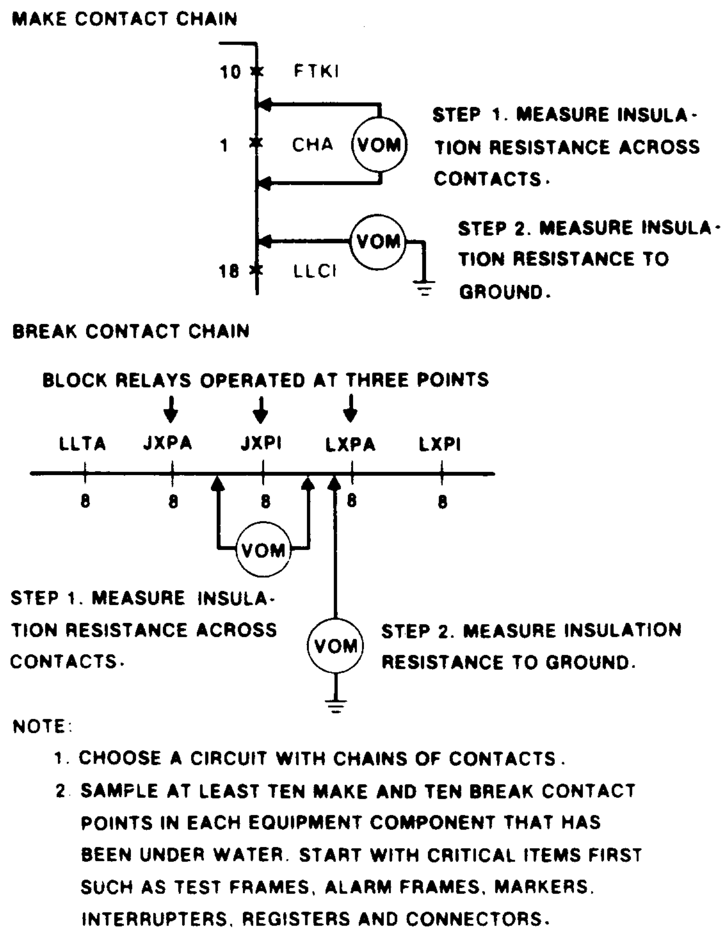
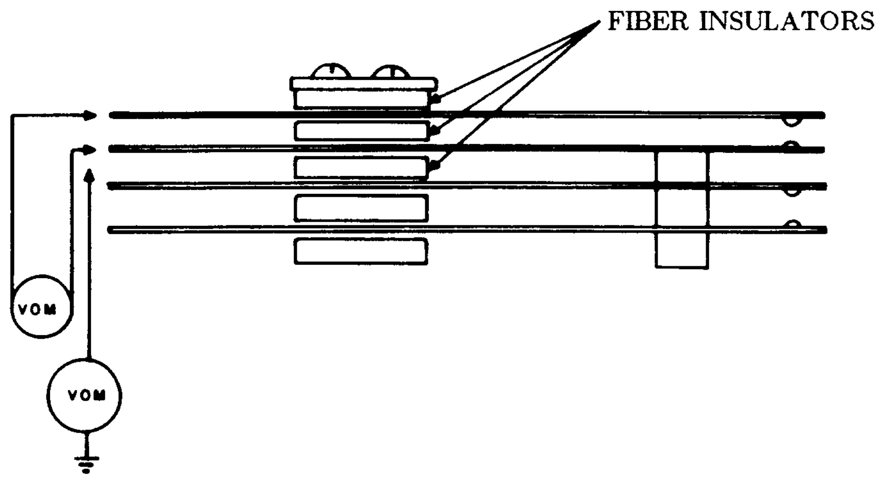


Figure 1. Method of Sampling Insulation Resistance Across Relay Contacts



STEPS:
1. CHOOSE A RELAY WITH SPARE CONTACTS IF POSSIBLE. IF NOT, REMOVE WIRES AT REAR. MEASURE INSULATION RESISTANCE ACROSS TWO REAR TERMINALS.
2. MEASURE INSULATION RESISTANCE TO GROUND.

NOTE:
SAMPLE AT LEAST TEN RELAYS IN EACH EQUIPMENT COMPONENT THAT HAS BEEN UNDER WATER. START WITH CRITICAL ITEMS FIRST, SUCH AS TEST FRAMES, ALARM FRAMES, MARKERS, INTERRUPTERS, REGISTERS AND CONNECTORS.

Figure 2. Method of Sampling Resistance Across Fiber Insulation of Flat Spring Relays

2.45 If equipment's battery potential was removed prior to flooding, most solid state electronic equipment can be restored by using the established procedures of flushing, drying, testing and inspecting. Ferrods, resistors, capacitors, relays and filters are examples of equipment that can be restored. Ferrods should be washed for at least 20 minutes for best results. All apparatus covers should be removed to aid in the drying process. Clean the relays and relay covers to prevent future contact troubles. Dry the filters with hot air blowers or hair dryers (120 °F maximum temperature) to eliminate electrical leakage to ground. Take resistance readings on all relays, capacitors and filters affected by water damage to determine the extent of leakage to ground.

2.46 All 6A memory modules affected by flood water should be unplugged and replaced whether serious electrolytic corrosion is present or not. The number of internal leads affected may be as high as 50 percent and the memory units would have to be completely disassembled to locate those affected. This would be impossible to do in the field and necessitates replacement of the unit. After the memory units affected by the flood are unplugged and removed, the connectors should once again be thoroughly washed and dried. Care should be taken during washing procedures to prevent the water pressure from damaging the ferrite sheets or breaking additional wires. Careful washing under frames may be necessary to preserve the integrity of a single equipment ground.

2.47 The 1A memory modules may be restored to an electrically operative condition using the established flushing and drying operations covered in paragraphs 2.08 through 2.28. However, the 1A module cannot be restored to a mechanically operative condition unless all cards and springs are replaced and all grit is removed completely from the memory module.

> **Note:** For temporary restoration of service, the module may be flushed and dried **without disturbing the memory cards.** This will permit restoration of service to the extent provided prior to the flood or water damage.

It is essential that the 1A card loader **not** be used to insert or to withdraw cards from a flooded memory module. Use of the loader could result in irreparable damage to the memory or the loader.

2.48 All flooded memory modules should be replaced as soon as possible because it is not possible to clean the modules sufficiently to permit the memory cards to be seated using the 1A card loader.

2.49 Some equipment, like ferreed switches, may be replaced immediately to reduce the time required to restore service. This same equipment, however, could be reconditioned and used later. The covers of the ferreed switches should be removed and inspected before restoration begins. During the washing operation, the hose nozzle should be directed to spray water between the cover and the body of the switches to remove the mud trapped in the switches. The recommended drying time for ferreed switches is approximately three days.

2.50 These procedures for reconditioning water-damaged equipment apply mainly for frame wiring and circuit boards. For equipment such as disk memories and tape drives, the manufacturer of the equipment should be consulted for recommended procedures.

Circuit Packs

2.51 The location of any circuit packs that have corrosion deposits on the contact fingers should be noted because the corresponding female connectors will have water on them. The connectors should be cleaned with the CK-22678 cleaning pad as covered in AT&T Practice 069-350-801, and the operation of packs in the particular connector should be watched. If packs were replaced and trouble persists, the connector probably will have to be replaced.

2.52 All connectors on the backplane must be examined. Any connectors found with indications of electrolytic damage or water residues should be replaced because they are known to be a source of erratic troubles that are hard to trace.

2.53 If water has gotten in between the base of the connectors and the backplane, corrosion damage may be impossible to see and repair because of the physical construction of the frame. The only recourse is to replace the frame if it causes trouble. Some external signs that may **not** always indicate a problem are visible evidence of water on both the back of the backplane and in the circuit pack connectors on the frame. Persistent troubles in a certain section of the frame that are not due to faulty circuit packs or backplane connectors are another indication of damage in this area. If damage is suspected but the frame is operating satisfactorily, the frame probably will continue to operate so long as it remains dry and there are not hygroscopic corrosive materials in the residues.

2.54 Circuit packs without serious corrosion may be reused after cleaning and testing. All circuit packs affected by water should be removed and all contacts should be cleaned thoroughly, including those in the connector housings. Any residue left in the connector or circuit pack area will be a source of future troubles when circuit packs are removed and replaced.

2.55 Circuit packs that are wet because of floods or leaks may be reconditioned, if they still operate, by dry brushing the corrosion products away as completely as possible. After dry brushing, the circuit pack should continue to function properly **if**:

(1) It passes all operational tests.

(2) Large amounts of chlorides are not contained in the remaining residues.

(3) No more than a quarter of the cross section of any of the lands or wires has been eroded.

Drying Solid State Electronic Equipment Damaged by Water Leaks

2.56 First prepare a list of items of equipment to be dried. Equipment should be considered in the following order of importance:

(1) Power Supplies.

(2) Ringing and Tone Plants.

(3) Master Control Center.

(4) Central Processor.

(5) Central Pulse Distributors.

(6) Master Scanners.

(7) Alarm Frame.

(8) Signal Distributors.

(9) Line and Trunk Scanners.

(10) Network Controllers.

(11) Switch Frames.

(12) Trunk and Service Circuits.

Follow the general drying and restoration procedures covered in paragraphs 2.15 through 2.42.

Reconditioning Solid State Electronic Equipment Damaged by Water Leaks

2.57 Damage to solid state electronic equipment usually is caused by water leaks from the roof, air conditioning units, burst pipes and condensation. Damage from water leaks can affect all of the equipment, or only some of the equipment, on one or more frames. Varying degrees of electrolytic corrosion may occur because this type of equipment normally has operating power supplied.

2.58 Minimize further damage to the equipment by removing power from the affected frames as quickly as possible. Cover the frames with a tarp or plastic sheet to avoid further wetting. Follow the methods described in paragraphs 2.15 through 2.28 to dry the equipment. The first step is to remove water from the equipment. Then, wipe the equipment with dry cloths, provide good air circulation and use portable hair dryers.

2.59 After the equipment is dry, carefully check any suspect frames for corrosion deposits and other signs of water damage. When checking circuit packs, look for signs of corrosion on the connector contact fingers. If there are any signs of corrosion, there also may be some damage to the corresponding connector on the frame. In addition, the condition of the backplane must be carefully checked, and all plug-in connectors for the backplane terminals must be examined. Methods for restoring these items are described in paragraphs 2.54 and 2.55.

3. REMEDIAL MEASURES AFTER WATER DAMAGE TO POWER PLANT EQUIPMENT

3.01 Cleaning of power plant equipment should be thorough and should be done with the knowledge that sand, grit, silt and other debris may penetrate to every part of submerged apparatus. It is particularly important that this debris be removed from moving parts and from ducts.

3.02 The apparatus should be disassembled completely, if possible. Clean water under moderate pressure should be used to flush out sand, silt, and other debris. (Insulation, brittle from heat or age, may be injured by too much pressure). After cleaning, all parts of the apparatus should be dried as specified below. Compressed air under moderate pressure, if available, will help remove water left from washing, but the air should not be directed in such a manner that water is forced into insulation.

3.03 Oil and grease should be removed with commercial solvent, such as CK-07860 petroleum spirits (Stoddard solvent) or varsol. Do not use a solvent or cleaning agent that will soften or damage the material being cleaned.

CAUTION: Petroleum spirits and varsol introduce a fire hazard. Have a fire extinguisher accessible at all times.

3.04 **Maintain good ventilation while using any cleaning solvents. Nearly all cleaning solvent fumes will cause death if they are inhaled in sufficient quantities for a sufficient length of time. Inhaling these same fumes in lower quantities for shorter periods of time will cause illness. It is important to maintain good ventilation while using any cleaning solvents.**

3.05 It is particularly desirable to clean and repack ball and roller bearings as soon as possible. The balls or rollers corrode quickly. If not cleaned within a day or two after the water subsides, they probably will have to be replaced.

3.06 Waste-packed bearings should be cleaned, the waste replaced, and the bearings relubricated.

3.07 The lubricant in oil ring bearings, gear cases and compensators may have completely or partially floated away. The bearings should be thoroughly cleaned and reoiled or regreased.

3.08 After cleaning, all parts subject to rust should be coated immediately with oil if they are not completely covered with a protective paint or finish.

Insulation Resistance

3.09 Before connecting power to the apparatus or putting the apparatus back into service, check that the insulation resistance of all coils to frame has increased to at least the value shown by the lower curve in Figure 3. Ideally, the insulation resistance should have increased close to the value shown by the upper curve. At the normal operating temperature, a resistance of 1 megohm (1,000,000 ohms) is considered a minimum acceptable value. But, as indicated by Figure 3's curves, a high winding temperature at the time the resistance is measured may make it impossible to measure a value close to 1 megohm.

To determine the final dry condition of the apparatus, the constancy of resistance measurements that are recorded at intervals of 1 or 2 hours is more important than the resistance values themselves. Some telephone power plant apparatus are sufficiently dried out after 24 hours of heating to be connected, as described in this Practice, and nearly all are sufficiently dried out after 72 hours. Some apparatus has been satisfactorily connected with no drying, but drying should take place, if at all possible.

Insulation resistance is highest when an apparatus is cold, and the resistance falls as the apparatus temperature increases. For this reason, insulation resistance decreases rapidly as the windings warm up in an apparatus that has not been dried before it is placed back in service. In such cases, the insulation can fail within minutes. **As little as one hour of heating in a well-ventilated environment can mean the difference between success and failure when restoring power plant apparatus.** Operating the apparatus at reduced voltage and no load for a short period is recommended, if conditions permit.

3.10 The methods of measuring insulation resistance most likely to be feasible in emergencies are using a CK-20538 Volt-Ohm-Milliammeter or equivalent, a Wheatstone Bridge, or a cable testing set. If the apparatus has electrostatic capacity, sufficient time should be allowed for it to become charged; that is, for the instrument deflection to become constant at a minimum value. Usually one minute is sufficient. Surface leakage may be troublesome in damp weather; therefore, the exposed conductors at such places as terminals should be inspected to see that the braid is not damp enough, or close enough to the metal, to provide a leakage path to frame.

3.11 The best method of obtaining and applying heat will depend on local conditions and the type drying equipment available.

Drying by External Heat

3.12 The drying procedures using external heat are in paragraphs 2.15 through 2.28. In addition, the air circulation obtained by operating a machine at low voltage or by some external force (for instance, by belt drive on the coupling of a motor generator set) is appreciable and will result in efficient drying if done in a warm room where the general humidity is kept low.

3.13 Sometimes, the submersion of apparatus while it is warm creates a vacuum that draws in water. If water is somehow trapped inside any apparatus, try to turn or shift the apparatus occasionally to allow the water to run out. Drilling small drain holes in the apparatus may be the most effective way to remove the water.

Drying by Internal Heat

3.14 If current is passed through windings (see Figures 4 and 5) the heat internally generated will assist in the drying operation. This method is often faster than drying by external heat but the heat is not dissipated readily and, unless watched carefully, there is danger of insulation damage. Wet insulation is more easily damaged than dry insulation and there is always danger that gas or vapor may develop sufficient pressure to force through the insulation. The current should never exceed full-load value and the temperature measured by resistance should never exceed 85 °C (185 °F). The temperature measured by thermometer on the outside of the windings should never exceed 65 °C (149 °F) since this temperature lags the inside temperature. Before breaking the circuit, particularly if direct current is used, reduce the current to near zero to prevent harm from an inductive kick.

3.15 Until commercial power is available, regular engine-driven reserve generators may be used as a source of low-voltage direct current for internal heating, and regular engine-driven reserve alternators may be used for generating alternating current.

3.16 Air circulation speeds drying when internal heat is applied, just as it does when external heat is applied.

Drying by Combination of Internal and External Heat

3.17 Drying by a combination of internal and external heat is the fastest and most thorough way of drying, but it should be carried out with the same precautions listed above for drying with internal heat only. Temperature readings should be taken frequently using the resistance method, and the method of controlling the temperature should be quick and positive. This combination of methods generally requires more equipment and skilled attention and is justified **only when the time factor is very important.**

Revarnishing of Coils

3.18 After coils are back in service for a few weeks and are thoroughly dry, apply a coat of air-drying insulating varnish wherever convenient, particularly to the end coils of machines and to coils where the finish is damaged. In no case should this be done before the insulation resistance is constant.

Drying Fractional Horse Power Machines

3.19 Machines such as centrifugal voltage regulators, 135- and 1000-cycle sets, multifrequency sets, small ringing machines, small charging machines, 4-cycle interrupters, drive motors, motor-driven tone machines, motors for rheostats and switches and small inverted converters are small enough to allow complete disassembly and removal to an electric oven for drying. It should not be necessary to dry these small machines using internal heat. If the surface is small enough and the stream of hot air is sufficient, it may be feasible to dry panel equipment by directing hot air against it.

DC Machines 1 HP and Larger

3.20 When commutators are submerged while warm, the cooling action of the water creates a partial vacuum inside that may draw in water that is difficult to remove. When the set is running, internal water will usually be thrown out by centrifugal force from machines of telephone office size. If it is not, it may be necessary, as a last resort, to loosen the V-ring, thus releasing the water and allowing hot air in. This should be done very carefully to avoid changing the alignment of the bars. It is best to wind one or two bands of friction tape (each band consisting of at least two layers) around the entire commutator before loosening the ring. To dry the commutator, hot compressed air may be forced in, or strip heaters may be wrapped around the surface to heat it. Space heaters clamped to the surface, or some other source of heat placed under the commutator, are additional methods of drying. Since a temperature over 100 °C (212 °F) may soften the mica binder, all of these heating methods must be monitored carefully. Never apply an open flame directly to the commutator.

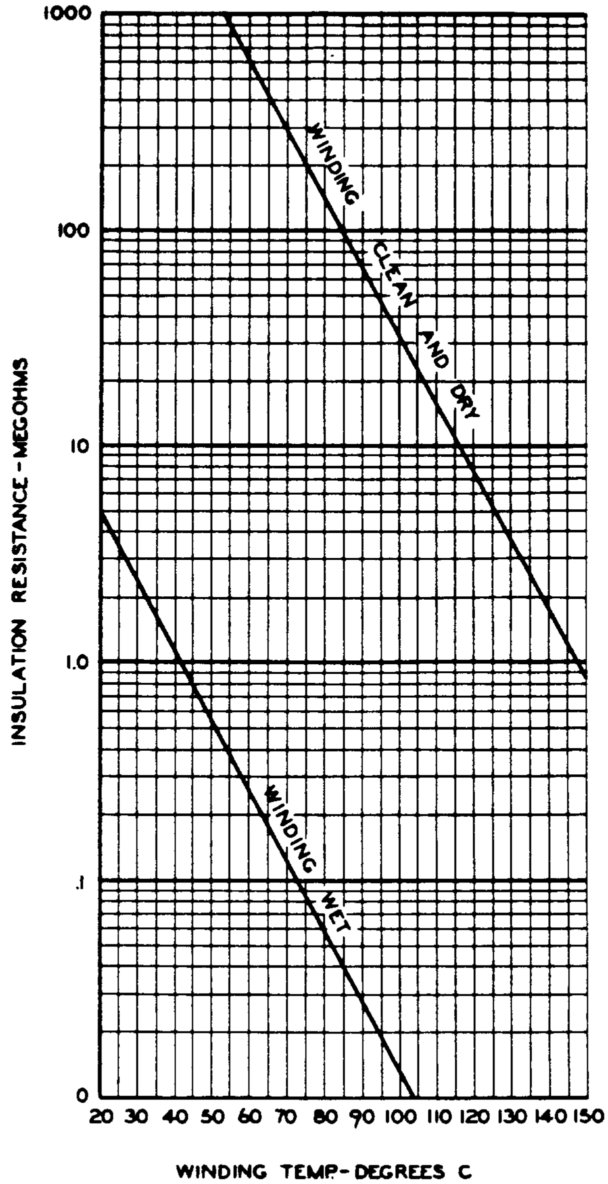


Figure 3. Insulation Resistance of Induction Motors

3.21 If a DC generator is being dried by short-circuiting the armature at the power board, it may be necessary to separately excite the field to hold current down to full-load value. Usually no harmful current will flow with normal excitation. If the machine has a series field winding, it should be reversed so that residual will not start a buildup that will carry beyond the full-load mark. If there is doubt, lower the circuit breaker setting or provide a separate small fuse before closing the field circuit.

AC Machines 1 HP and Larger

3.22 When wound rotor induction motors are being dried by short-circuiting and blocking the rotor and applying voltage to the stator, the voltage required will be about 20 percent of normal. This voltage should be adjusted as necessary to limit the stator and rotor temperatures to 85 °C (185 °F) read by resistance, or 65 °C (149 °F) read by thermometer.

3.23 When an AC generator is being dried by applying current to the armature, the field windings should be short-circuited to avoid high voltage and also to circulate induced drying current.

Control Apparatus

3.24 Small insulating parts, such as fiber washers, fiber spacers and paper wrappings may swell and warp sufficiently to justify or require their replacement. Careful examination should be made of such parts, both before drying to see whether the necessity of replacement is evident, and after drying to see whether warping and cracking has become serious.

3.25 The cleaning instructions given in the following paragraphs will apply particularly to such items as rheostat bearings, contactor bearings, knife edge or pencil bearings in power-type relays, and current-carrying contacts.

3.26 Cartridge fuses that are water damaged should be replaced if an adequate supply is available. If the fuse supply is inadequate, the fuses should be removed from their clips and cleaned. If the fuse elements are not open and the ferrules are reasonably tight on the barrel, thorough drying should render them ready for service again.

3.27 Low-voltage air frame and high-voltage circuit breakers, except the molded case types, may be disassembled, cleaned and dried satisfactorily. However, the potential coil and series coil (if wound with small wire) and any fiber parts and springs may have to be replaced. Molded case types always should be replaced.

3.28 Autotransformer-type compensators may be disassembled, cleaned and dried satisfactorily. If they are of the oil immersed switch type, fresh oil should be added after the oil immersed parts are cleaned.

3.29 Resistance type (KS-5309) compensators may be reconditioned; however, the carbon pile resistance units probably will have to be replaced.

3.30 In general, meters that are water damaged should be replaced. Any shunts associated with meters, if corroded, should also be replaced.

3.31 Power distribution panels (unpowered) may be cleaned with a hose. Slate may then be wiped off with one of the solvents described in paragraph 3.03 and then oiled with the oil normally used for panel maintenance. Asbestos panels, after washing, should be wiped clean with one of the solvents.

3.32 Telephone-type relays, or other relays having coils that have not been impregnated, should be discarded. In cases of necessity, some of these relays may be found usable for a time after drying. But the small percentage found usable, with almost certain drastic decrease in life, makes it advisable to plan for complete replacement.

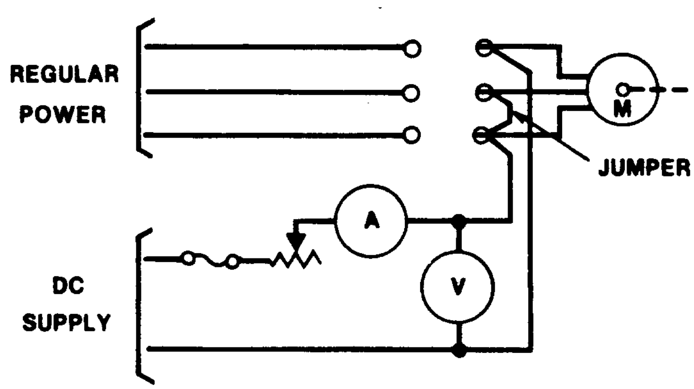


Figure 4. Schematic for Drying a 3-Phase AC Machine While Stationary by Heating with Low-Voltage DC

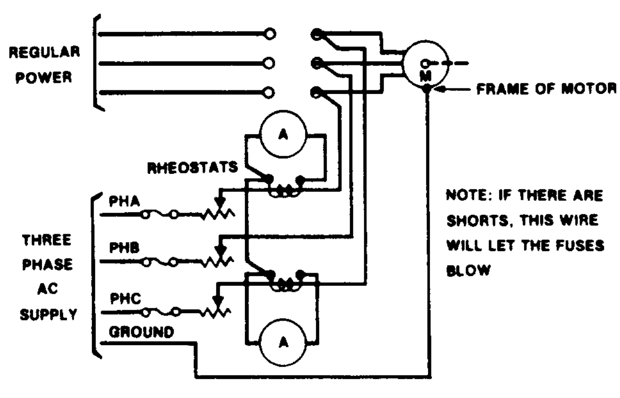


Figure 5. Schematic for Drying a 3-Phase AC Machine While Stationary by Heating with Low-Voltage AC

3.33 AC and DC switch gear generally can be cleaned and dried satisfactorily.

3.34 Voltage and voltmeter relays that are water damaged generally should be replaced.

3.35 Power-type relays and contactors, such as Dunco, Signal, and Cutler-Hammer, may be reconditioned by a thorough cleaning and drying.

3.36 Transformers and inductors probably require replacement if they were not impregnated. This is particularly true of coils composed of many turns of small wire because the swelling and warping of insulation may cause breakdowns between turns. However, nonimpregnated coils may be sufficiently reconditioned to give service for a short time.

3.37 Starters may be disassembled, cleaned and dried satisfactorily because they are mainly a grouping of contactors, overload relays and resistances.

3.38 Voltage regulators similar to the cam type may be disassembled, cleaned and dried satisfactorily. Exceptions are the Warren cam-driving motor and the rectifier, which may have to be replaced.

Open Wiring

3.39 Stitching on all local forms should be cut and the leads separated so they can be dried.

3.40 Sheathing of switchboard-type cable should be stripped to a point a foot or so above the line of submersion and the wires then separated so they can be dried.

3.41 Wiring with varnished cambric insulation should be replaced. Varnished cambric tape on bus bars also should be replaced.

Wiring in Conduit

3.42 Wire that does not have rubber or PVC insulation cannot be satisfactorily dried within a reasonable time while in conduit. It should be replaced.

3.43 Conduits with rubber or PVC covered wire should be drained of water by opening fittings or drilling holes at low points of the line. The conduit should then be blown out with compressed air (heated, if available). The insulation should be checked, as outlined in paragraphs 3.09 and 3.10, to see that an insulation resistance of at least 1 megohm has been reached.

3.44 If leads are removed from the conduit, the conduit should be flushed, swabbed with a fish wire and strong cloth, and then dried with compressed air. Do not use a cloth large enough to get stuck in the conduit.

Armored Cable

3.45 Lead covered cable of the switchboard type should be replaced if water has entered the ends.

3.46 Frequently, lead-covered, rubber-covered and flexible steel-covered cable that was water damaged may be reused. Little can be done to dry such cable, except from within. If low voltage, high-current power is available, the leads of the cable wires may be shorted or grounded and current of about the rating of the leads passed through them. If this does not bring the insulation resistance up to at least 1 megohm, the leads should be replaced.

Batteries

3.47 Batteries, especially the sealed type, seldom are seriously harmed by being submerged. The high specific gravity of the electrolyte keeps it from mixing with water if no charge is applied. After the water has receded and the room and equipment are thoroughly cleaned, the electrolyte should be siphoned off for a distance of an inch or so below the low electrolyte level line. During this operation the siphon nozzle should always be held very near the surface, to remove water rather than electrolyte. Open cells are inclined to collect foreign matter in harmful quantities, and particular attention is required if the cell covers are broken or displaced. Contact the local Environment Protection Manager for the proper methods to be used in disposing of both electrolyte and water removed from batteries.

3.48 After cleaning and siphoning, quickly fill the cells with electrolyte, to prevent any of the plates from being exposed to air for longer than approximately 20 minutes. Give the batteries an equalizing charge as soon as possible. The electrolyte should be analyzed by the battery company promptly to determine whether complete replacement of the electrolyte is advisable.

3.49 Recharge the usable batteries after flood waters subside by using portable DC engine generators, rectifiers or, possibly, welding machines. A fast, reliable procedure is to replace the battery when the total battery voltage exceeds 130 volts.

3.50 When batteries are brought in from another location, it may be advisable to arrange for the trucking company to send along personnel to unload the cells. Moving 24 or more cells, each weighing several hundred pounds, may require additional help.

3.51 Before positioning a replacement battery, particularly on an upper floor, consider the floor strength. The building engineer should approve putting the new cells in place.

3.52 When a replacement battery is installed on a dry upper floor or at another location away from the flooded battery, new discharge cables may be connected to the discharge cables on the old battery, to the power board, or directly to the fuse boards, depending on what is most advantageous for the particular situation. Disconnect the flooded battery before connecting the replacement battery.

Rectifiers

3.53 Semiconductor type rectifiers usually can be cleaned and dried satisfactorily. The controlling relays should be thoroughly dried and cleaned. Some of the transformers may not be totally impregnated; if these transformers are not dried thoroughly, a heat problem may develop.

3.54 All metallic-type rectifiers may be cleaned and dried, but a change in tap connection may be necessary to obtain the required output. If the tap change does not provide the required output, the rectifying element should be replaced.

3.55 Clean and dry rectifiers following this procedure:

(1) Wash the device down with clear water.

(2) Bake all transformers and inductors for 12 to 16 hours at temperatures not over 150 °F.

(3) Wipe or blow off all excess water from stacks.

(4) Dry at temperatures not over 130 °F for 12 hours.

(5) Connect AC for a 10-minute period with no DC load.

(6) Disconnect AC, and connect a light DC load. Connect AC, and gradually increase DC load to full rating.

Transformers

3.56 Transformers in telephone offices usually are of the instrument type or of the small air cooled power type and may be satisfactorily dried with external heat. Follow the drying precautions listed here. A combination of internal and external heat should prove effective. Low-voltage direct current may be applied up to the rating of the windings, or one winding may be short-circuited and the other winding excited sufficiently with AC current not exceeding full load to flow in the secondary. At the normal operating frequency, the primary voltage provided by this arrangement will be very low, possibly in the order of 1 to 2 percent of the normal operating voltage.

3.57 Oil-cooled transformers usually will be reconditioned by the power company. However, they may be emptied of liquid, cleaned, and dried in the case by forcing warm air in the oil drain hole. Drying by internal heat may be accomplished by emptying the liquid, short-circuiting the secondary, and exciting the primary sufficiently to keep the temperature between 85°C to 90°C (185°F to 194°F), read by the resistance method. Probably about 20 to 25 percent of rated secondary current will accomplish this. The larger the transformer, with its greater volume of metal and insulation, the more necessary it is to follow the power company precautions. It is recommended that drying be done under the supervision of the power company.

Engine Driven Machines

3.58 Two basic types of engines are used to power stationary emergency alternator sets. They are the diesel engine and the gas turbine.

Diesel Engine Driven Alternators

(1) As soon as possible, disconnect the engine from all control and starting batteries. Also disconnect the AC source to the rectifiers used to charge these batteries.

(2) Hose down those sections of the engine, alternator and controls that were below the high water mark. Direct the hose, to avoid getting water into the interior of the engine.

(3) If the electrical controls, alternator or starter windings were hosed down, direct an external heat source at these items to start the drying process, and then proceed to (4).

(4) Remove the oil dipstick from the engine and determine if water has entered the crankcase. If water is detected, drain the crankcase and refill the crankcase with new oil to the add-oil mark on the dipstick. Clean and/or replace the air intake filter and oil filters.

(5) Remove the air intake filter and disconnect the exhaust pipe at the engine exhaust manifold. Remove all water observed in both the intake and exhaust manifolds.

(6) By use of a barring tool or other **hand-operated** device (do not use the starting motor), attempt to rotate the engine two full rotations in the normal direction of rotation. If the engine binds before two rotations are accomplished, reverse the direction of rotation until the engine binds and then again rotate the engine in the normal direction. Continue the above procedure until two rotations in the normal direction of rotation without binding are accomplished.

(7) If water was observed in (5) or binding occurred in (6) redrain the oil crankcase and refill it with new oil to the full mark on the dipstick.

(8) Check to see that the electrical controls and starter have dried sufficiently to allow them to be energized. Short the exciter field. Reconnect engine batteries and test the control circuits to make sure the protection circuits are working.

(9) Reconnect the inlet filter and exhaust system and then start the engine. Leave the external source of heat directed at the alternator. Continue to operate the engine with external heat applied to expedite drying of the alternator.

(10) When the alternator windings are dry, remove the short from the exciter field and return the alternator set to service.

(11) As soon as possible after the flood emergency, drain the lube oil and replace all oil filters.

Gas Turbine Driven Alternators

(1) Follow steps (1) through (3) in the procedures above for diesel engine alternators.

(2) Clean out the compressor air intake duct system.

(3) Open the combustor drain and check that all water has drained from the turbine engine.

(4) Remove the oil dipstick from the engine and determine whether water has entered the oil sump. If water is detected, drain the oil and replace all oil filters. Refill the sump with new oil to the add-oil mark on the dipstick.

(5) Proceed with step (8) in the procedure above for diesel engine driven alternators.

(6) If water was observed in steps (3) or (4) purge the water and then crank the engine for 20 seconds (no fuel injection -- no ignition). Then redrain the oil sump and replace the oil filters. Refill the oil sump with new oil to the full mark on the dipstick.

(7) Leave the external source of heat directed at the alternator. Start and run the turbine with external heat applied to expedite drying of the alternator.

(8) Proceed with steps (10) and (11) in the procedure above for diesel engine alternators.

Electrolytic Capacitors

3.59 Dry-type electrolytic capacitors probably will be reusable. However, there may be cases where cooling has created a vacuum strong enough to draw in water that will cause failure of the capacitor within a few days.