RECONDITIONING CENTRAL OFFICE AND PBX EQUIPMENT DAMAGED BY WATER

CONTENTS PAGE

1. GENERAL

1.01 This section provides general recommended recovery procedures after water damage to equipment in a central office or PBX, including the power plant. Detailed procedures for assembly, disassembly, or adjustment of apparatus are covered by sections on the particular apparatus involved. This section contains information previously covered in Section 069-392-800 and Section 167-790-811.

1.02 Water damage to buildings, central office and PBX equipment may result from a variety of different causes. Among them are floods, defective plumbing, rain or snow entering windows, ventilation or temporary building openings, fire fighting efforts, etc.

1.03 The importance of thorough planning before a water-damage emergency cannot be overemphasized. Thorough planning and organization as covered in Section 010-120-010 can materially reduce the time required to restore service. Section 010-120-010 also covers the general plan for abandoning a central office or PBX due to rising water.

2. REMEDIAL ACTION AFTER WATER DAMAGE TO CENTRAL OFFICE AND PBX EQUIPMENT

General

2.01 Experience shows that water-damaged central office and PBX equipment can generally be reconditioned and reused without requiring subsequently increased maintenance effort provided that: (a) electrolytic corrosion did not occur to any appreciable extent, (b) equipment is promptly flushed with clean water, (c) ***it is thoroughly dried out and cleaned before battery potential is again applied, and (d) drying solvents or agents are avoided.***

2.02 The decision of whether replacement is necessary in cases of serious electrolytic corrosion must be passed on a judgment evaluation of the situation. For obvious reasons, no electrical measurements or operational tests should be attempted at this time. The criteria to be used in the evaluation are, therefore, entirely visual, subject to individual judgment, and cannot be easily defined. External evidence must be used as a guide to predict seriousness of internal damage to relay and magnet coils and various insulation materials. The following may help to make the restoration versus replacement decision.

(1) It is important to distinguish between electrolytic corrosion, and the relatively harmless non-electrolytic or chemical corrosion. Commonly used nickel-silver and brass contact springs are not likely to be easily corroded by short exposure to water in the absence of electrical potentials, whereas zinc-coated parts, such as switch castings and mounting plates, are relatively susceptible to this type of corrosion. Therefore, nickel-silver and brass springs provide the best indicators of electrolytic corrosion. If there are concentrated bluish-green deposits on these metals, particularly at spring pileups, electrolytic corrosion is probable. Non-electrolytic corrosion products are most often distributed

over larger areas somewhat uniformly. They should, if possible, be removed before equipment is restored to service to prevent contact contamination, but are not otherwise harmful.

(2) As stated before, severity of electrolytic corrosion will vary with (a) the duration of time that potential remains on equipment during the flood, or later if it is again applied while the equipment is still damp, and (b) the amount and kinds of salts in the water that can form electrolyte. It, therefore, bears repeating that whenever possible, potential be removed before flooding occurs. Probabilities of whether potential remained on the equipment during flooding, and if so, as precise knowledge of the duration as possible will be of help in differentiating between electrolytic and non-electrolytic corrosion.

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

(4) Those without previous flood experience must resist a strong temptation to replace flooded equipment solely on the basis of its appearance when water first recedes. Mud, silt, debris, and general disorder are ***not*** the damage criteria on which the replacement-restoration decision is based. These must first be removed before the true condition of the equipment can be established. The basic criterion is the degree of electrolytic corrosion that has occurred. The penalty for reconditioning equipment that should have been replaced lies in piecemeal replacement of components such as relay and magnet coils.

(5) There obviously will be times when qualified appraisers cannot quickly reach flooded offices to decide whether reconditioning is a good risk. In such an event, the local plant supervisor must decide upon immediate steps. Of course, he will be able to easily tell if there is no electrolytic corrosion or if it is severe. If there is no such corrosion, restoration procedures covered in the following statements should be started at once. If electrolytic corrosion is severe, general "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 to seek their advice. On the other hand, it may be advisable to attempt minimizing outage time in these marginal cases by starting restoration procedures without waiting for an appraisal. The advantage of such action is apparent where damage proves minor. It is frequently helpful to remove samples of components from the frames for measurements and/or laboratory studies in order to judge the extent of the damage.

2.03 Because of road or other conditions, a few cases have occurred where access to water-damaged offices and PBXs has been impossible for extended periods. In some of these cases, the equipment had become quite thoroughly dried out by the time attention could be given to it. In order to quickly restore service, the equipment was not flushed off with water, but it was "dry cleaned" by means of brushes, vacuum cleaners, etc. It is recognized that this procedure involves a certain amount of calculated risk. It is not possible, with dry cleaning techniques just mentioned, to completely remove all the fine binding clay deposits that adhere to the equipment. These deposits may contain salts that will, after equipment is re-energized, permit electrolytic corrosion or electrical leakage during high humidity periods. Therefore, it appears prudent to make visual inspections of such equipment at intervals during high humidity periods for evidence of electrolytic corrosion. These inspections should be supplemented by insulation resistance measurements to help detect deterioration due to this possible cause.

2.04 The general plan found effective in past emergencies for promptly reconditioning water-damaged central office and PBX equipment not judged to be seriously affected by electrolytic corrosion is given in Table A.

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

TABLE A

PLAN FOR RECONDITIONING WATER-DAMAGED CENTRAL OFFICE AND PBX EQUIPMENT

STEP	OPERATION	PARAGRAPH REFERENCE
1	Flush mud and debris off equipment with clean water aided by brushing.	2.06—2.07
2	Clean and mop equipment room floor while equipment is being flushed.	2.11
3	Drive surface moisture off equipment with compressed air. Do not use compressed air for cleaning solid-state electronic equipment. See Section 069-305-301.	2.09
4	Dry the equipment out using warm air and fans to prevent hot spots.	2.12—2.27
5	Clean electrical contacts and contact surfaces of the equipment.	2.30 2.35—2.38
6	Lubricate mechanical equipment where necessary.	2.31
7	Replace equipment that cannot be restored.	2.33—2.34
8	Make operational tests. The equipment should be checked for excess electrical leakage before energizing. Energizing equipment while partially wet usually causes electrolytic corrosion.	2.28 2.29
9	Place equipment back into service.	2.28
10	Pressure-clean equipment to remove residual slit and debris if needed.	2.40
11	Make periodic post-cutover inspections for reasonable period.	2.43

Flushing and Related Operations

2.06 As water recedes or is pumped from the building, a ***clean*** water distribution system should be set up according to the individual office plan as described in Section 010-120-010. It is an absolute necessity that plenty of ***clean*** water is available for the following operation.

2.07 ***Flushing should be started as soon as possible*** for two reasons: (a) to clean equipment of mud while it is still in the semi-fluid state, and (b) to remove absorbed salts from insulation material that might otherwise later result in electrolytic corrosion during high humidity periods. 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, like cement.*** The flushing procedure is as follows:

(1) Use a garden hose with an ordinary adjustable nozzle. Adjust the nozzle for a spray of about 45 degrees spread from the end of the nozzle. The force of the water spray should not be any stronger than is required to remove the silt and debris.

(2) Remove the equipment covers and begin flushing at the high water mark. Do not dampen equipment which has not been subjected to water damage.

(3) Start flushing down the back side of the equipment first, then the front side.

(4) Flush in a precise manner (i.e. wash down the equipment one relay at a time).

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

2.08 After flushing is completed on cloth covered cables, open up sewn cable forms, bank multiples, switchboard cables, etc, as far up as they appear wet or a foot above the high water level, whichever is greater. In one instance, vertical runs of new plastic covered switchboard cables were dried out without being slit open. A small slit was cut in the sheath about a foot above the high water line. Then the small nozzle of an air compressor was inserted in the slit. Moisture was blown out the lower end of the cable.

2.09 Immediately after flushing is completed, surface moisture remaining should be removed with air compressor sets. This can be started on upper equipment while that below is still being flushed. It may be necessary to use dry cleaning cloths to remove some of the moisture. These items should preferably be of the type commonly used in central offices. Start at the high water mark and work downward.

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

Caution: Use of rust inhibitors is not recommended since they may leave gummy deposits on relay parts, such as backstops, and interfere with operation.

2.11 While equipment is being flushed, the equipment room floor should be cleared and mopped. Mopping may be required on a continuous basis during restoration. Use garden hose and spray and mop floor as required.

Drying Operations

2.12 Prepare a priority list of the items of equipment to be dried first. Equipment should be considered in order of importance such as:

(1) Power and tone supplies

(2) Alarm and interruptor frames

(3) Test frames

(4) Markers

(5) Registers

(6) AMA equipment

(7) Connector

Items such as senders and trunks can be dried last and in sufficient quantities to provide basic service.

2.13 While some types or frames of telephone apparatus may be dried off sufficiently to be usable in a day or so, other equipment types may require a much longer drying period. Some components may not be capable of being dried out to give satisfactory operation or are permanently damaged by water. In this latter category are components enclosed in a permanent can cover but not hermetically sealed, such as 293A reed relay packs, 120 repeat coils, the plug-in base of 275- and 276-type sealed mercury relays and 280 type relays. The black outside coating of cold cathode tubes used in timing circuits is destroyed by water, making the tube sensitive to light. Water can also swell and permanently damage resistance coils in step switches and frequently tubular capacitors may be damaged. Older types of insulation such as the phenol fiber in pile-ups on "U" type flat spring relays are very slow to dry, and the use of proprietary drying, water-displacing, or anti-moisture treatments does not help. Equipment with crossbar switches and wire spring relays, on the other hand, is easier to dry and may be safely energized sooner.

2.14 Apparatus and wiring forms will dry more quickly if opened sufficiently to allow free circulation of air.

2.15 The drying of dampened equipment may be accelerated by evaporating moisture into the air and exhausting it out of the building. The ability of air to carry moisture is increased by raising its temperature. As an aid in maintaining optimum absorptive capacity of the air during the drying operation (a) its temperature should be raised to the highest level consistent with personnel safety, and (b) regardless of the temperature, movement of outside air through the office should be aided or controlled as necessary to hold relative humidity below 50 percent. Relative humidity should be monitored near the center of the room with a psychrometer. It is unlikely that the temperature at earlier restoration stages will have to be raised to intolerable levels to attain the relative humidity objective. At later stages, it may be necessary to permit the relative humidity to somewhat exceed 50 percent in order to hold the temperature to a bearable level.

2.16 If power is not available and the outside humidity is appreciably lower (at least 20%) than the inside humidity, it may be better 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 dried by one or a combination of the following methods.

(a) By using the office air conditioning, if undamaged.

(b) By using the office heating and ventilating equipment, if undamaged.

(c) By using fans to circulate air through the building.

(d) By using portable sources of heat as shown in 2.19.

2.17 Relatively inexpensive indicating psychrometers with hair elements will be satisfactory for measuring the relative humidity. If available, a model accurate within a maximum error of 5 percent and an average error of 2-1/2 percent should be chosen.

2.18 Thermometers with scales exceeding 130°F should be provided to monitor equipment temperatures during restoration work.

2.19 Several portable sources of heat have been found to raise temperatures of damp equipment. The best sources are 250-watt infrared heat lamps equipped with swivel or clamp-on type sockets so that they may be fastened to office frames or racks made up to hold them. Care must be taken to prevent local overheating of components with these lamps. Another is the family of commercial heaters. A source found good for spot drying is the hand operated hair dryer. The portable home hair dryers with the plastic head bonnets and flexible hoses are even better as they do no require constant holding. A portable blower equipped with a heat nozzle such as the Ideal Hand-Type Cleaner, light duty model (1/2 Hp.), equipped with and Ideal Heater Nozzle may be more satisfactory than hair dryers for spot drying. Ventilating heaters normally used by the construction forces to ventilate manholes may be placed at the bottom of the equipment with the airstream directed upward. Salamander type heaters are a source of open flame and should be used only if necessary and as a last resort. Salamander type heaters should probably not be used at all around electronic or switching equipment because of the large amount of soot they give off.

2.20 An attendant should be present at all times during the drying operation to make sure that equipment is not overheated. If necessary, electric fans may be used to assure proper distribution of warm air to prevent hot spots. If one has to resort to the use of portable propane space heaters, fans must be used to distribute heat, and enough doors and windows must be opened to provide adequate ventilation. Also, possible fire hazards associated with the use of this equipment should be kept in mind. Solvents or aerosol sprays should not be used near open flame type heaters or driers.

2.21 ***Do not directly apply heat lamp rays to panel banks. This would soften the tar binder in the banks. Tar might flow and spread on the terminals.***

2.22 ***Telephone switching equipment should not generally be subjected to temperatures above 130 F, or damage may result to capacitors and other "potted" circuit elements.***

2.23 Two 60-volt arc welding sets connected in series may be used to energize heat lamps, emergency lighting facilities, etc. It may be necessary to multiple several sets to carry the load. A great deal of generating capacity will be required to energize the heating devices used in restoration work. Usually portable or trailer mounted engine alternators are used for this purpose.

2.24 Approved fire extinguishers should be kept nearby during the drying operation. Fire detection systems should be tested and made operable for use during drying operations.

2.25 ***Do not use any desiccants. Desiccants have not been found useful to dry water-damaged central office or PBX equipment.*** This is because relatively limited absorption capacity of these materials would make very large quantities necessary. Further, use of desiccants will generally produce a contact contamination problem.

2.26 Aerosol dryers should not be used because they may contain chemicals which will damage the equipment. The use of contact cleaner is ***not*** recommended.

2.27 Commercial dehumidifiers have not been very effective during restoration work because of their limited capacity to remove water. Use of them after restoration to remove residual moisture may be considered, but is not generally recommended.

Insulation Resistance Requirements and Measurements

2.28 The net normal insulation resistance on a connection through a central office or a PBX is generally about 15 megohms. ***Equipment and cabling will, however, generally function satisfactorily without damage after the drying operation has raised the insulation resistance to 3 megohms or more.*** This resistance level, or course, assumes absence of relatively abnormal conditions such as silver migration, degradation of rubber insulation, etc. Insulation resistance measurements should be made frequently on water damaged equipment and compared to measurements on identical dry equipment. This will serve as a check on the drying rate and also as a guide as to when the equipment can be returned to service. See Fig. 1, 2, and 3 for example of insulation resistance measurements and drying time in equipment.

2.29 The insulation resistance may be measured by using the KS-20538 Volt-Ohm-Milliammeter or equivalent, Wheatstone Bridge, or other cable testing equipment. Use automatic line insulation test frames where available.

Operations After Drying

2.30 Corrosion products lower insulation resistance in presence of humidity. Hence, they should be removed. If left on equipment, the corrosion products will continually be dislodged and cause contact contamination and other trouble conditions. A stiff brush is effective to remove corrosion products if used in conjunction with a vacuum cleaner. Nylon bristle brushes of various sizes, tooth brushes, and teletypewriter cleaning brushes have been used with good results.

2.31 Equipment should be relubricated in accordance with appropriate BSPs. Relay and other contacts should be cleaned if inspection or operational tests disclose contamination. Many will need to be cleaned.

2.32 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. The lamp will glow if the supplied circuit is grounded. Weatherproof "pig-tail" type lamp sockets are convenient for this test purpose. Similarly, 13-type resistance

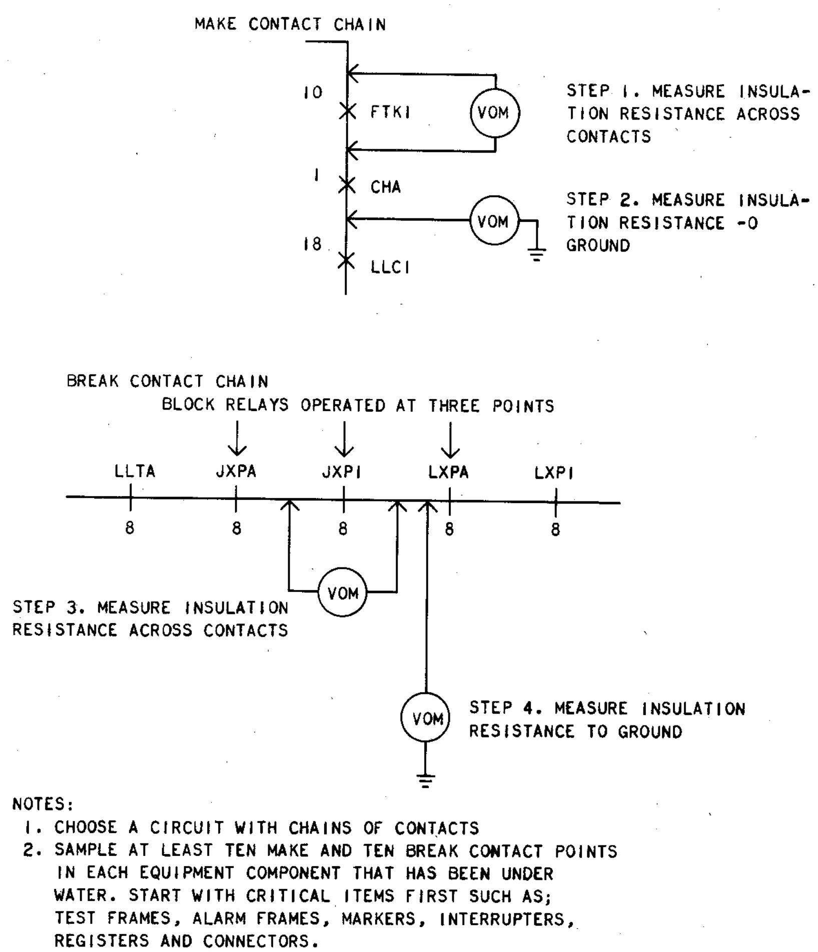


Fig. 1—Method of Sampling Insulation Resistance Across Relay Contacts

lamps may be used for preliminary testing of ringing supply circuits before the fuses are inserted.

2.33 The following may be required in panel offices:

(1) Replace cork rolls.

(2) Duplex drive motor should be reconditioned as outlined in 3.19.

(3) Inspect the friction roll and gear reduction drives to see if water has entered. If water has entered, oil in the drives should be drained and refilled in accordance with appropriate BSPs.

2.34 Because of their physical construction, some components can not be dried out because of liquid water trapped inside covers, etc. Among the items in this category are:

(a) 293A reed relay packs

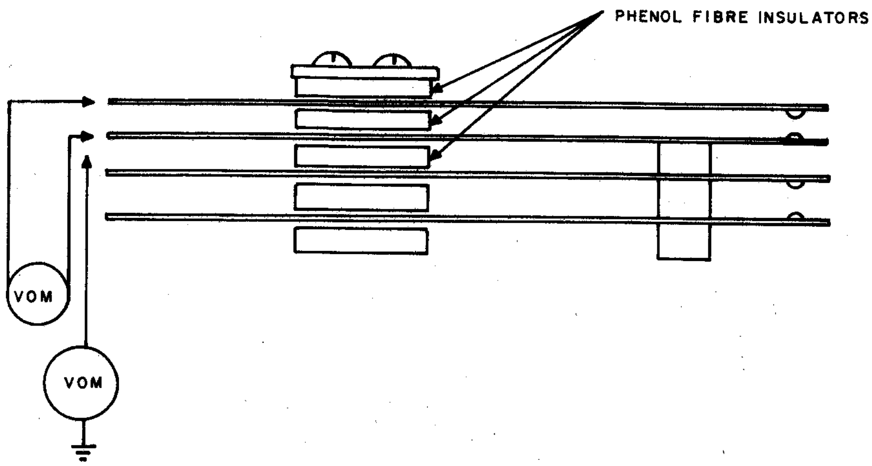
(b) 120 type repeat coils

(c) 275 and 276 type mercury relays

(d) Recent manufacture 177B networks which are not potted

(e) 280 type relays

2.35 Some silt will remain on panel and step-by-step banks after they have been flushed and dried. It should be removed. Use a suitable stiff brush and a vacuum cleaner.



STEPS:
1. CHOSE 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.

Fig. 2—Method of Sampling Resistance Across Phenol Fibre Insulation of Flat Spring Relays

2.36 Step-by-step banks should be cleaned. All deposits between terminals must be removed or the gritty particles that they contain will cause excessive wiper and terminal wear. For procedures on cleaning and reconditioning of step-by-step equipment, refer to the 069 Division of the BSPs.

2.37 Panel multiple brushes, guide combs, sequence switches, commutators, commutator brushes, and multiple bank terminals should be cleaned and if necessary retreated. For procedure on cleaning, treating, and reconditioning of panel equipment, refer to the 069 Division of the BSPs.

2.38 Crossbar switches and relay apparatus should be cleaned and reconditioned in accordance with procedures in the 069 Division of the BSPs.

2.39 Alarm circuits should be treated and troubles cleared. Operational tests of associated equipment should be made before it is placed back into service.

2.40 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 probably be filtered because of the large amount of oil normally found in contractor air compressors. Most offices will require it. ***Do not*** use compressed air for cleaning in solid-state equipment. Appropriate BSPs covering pressure cleaning of the various types of equipment should be followed. See Section 069-305-301.

2.41 Avoid wholesale individual contact cleaning programs unless there are definite indications that dirty contacts are a problem. When cleaning contacts refer to Section 069-306-801. Do not use burnishers or files on contacts.

2.42 Reenergizing the equipment requires the same priority order as given in 2.12. Choose small segments of equipment that show 3 megohms or more of insulation resistance. If fuses operate, continue drying and take sample insulation resistance measurements. It is recommended to use the schematic diagrams to isolate and eliminate hard faults that cannot be cleared by normal cleaning and drying techniques.

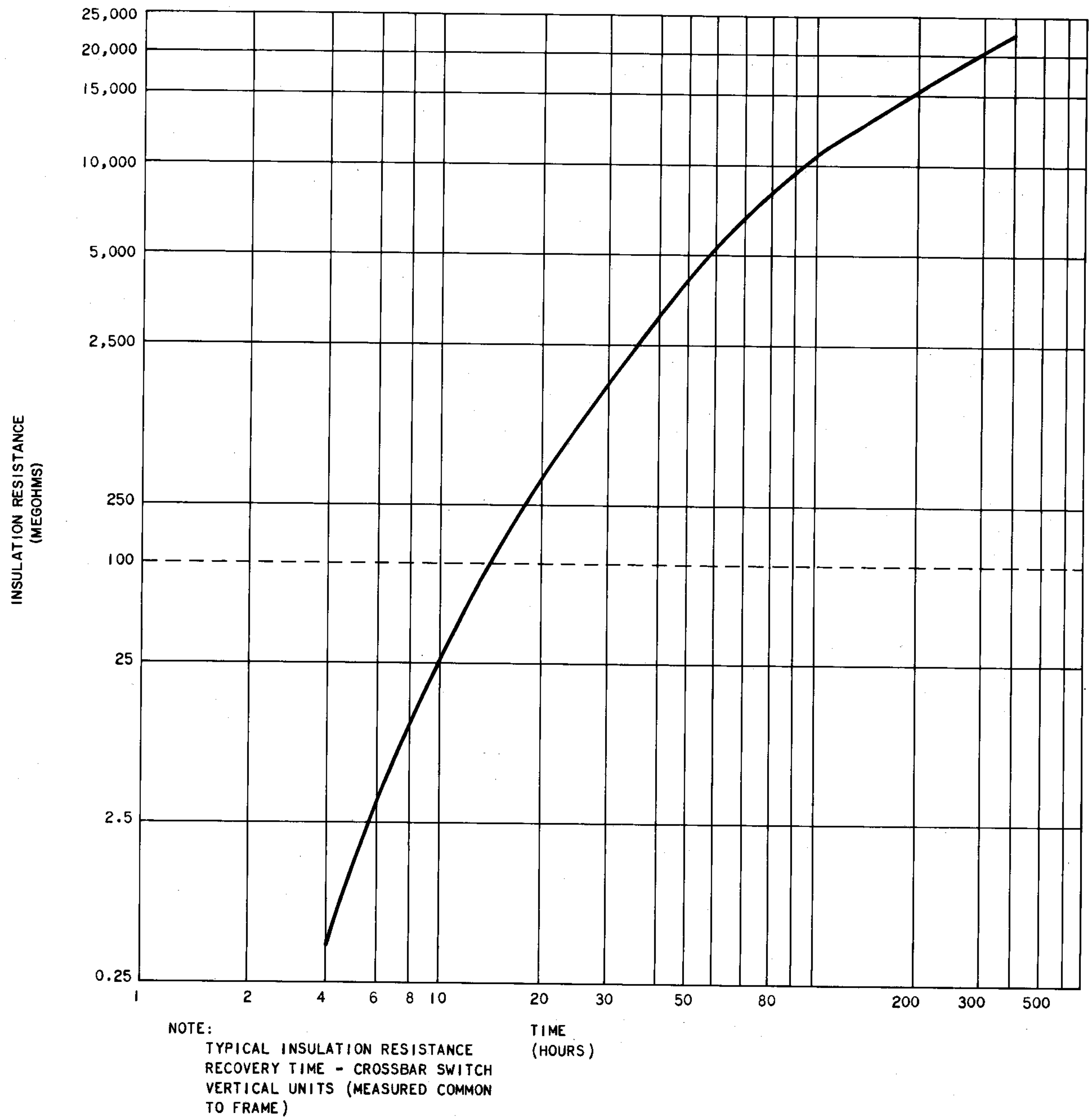


Fig. 3—Insulation Resistance Recovery Time—Crossbar Switch Vertical Units

2.43 It is desirable that maintenance engineering and plant people familiar with past performances make several post-cutover inspections of water-damaged central office and PBX equipment that has been restored to service. A review of office performance records before an inspection will often disclose items warranting close scrutiny. The inspections should be fairly frequent, possibly at 2-week intervals immediately after restoration, decreased in frequency later and eliminated at, say, six months. This procedure will ensure detection of any abnormal conditions that may develop. An example of this is shortened wiper life due to presence of residual silt not removed from step-by-step banks.

Solid-State Electronic Equipment

2.44 Generally, solid-state electronic equipment affected by water damage while energized will have to be replaced.

2.45 If the battery potential has been removed prior to flooding, most solid-state electronic equipment can be restored by using the establishing procedures of flushing, drying, testing, and inspecting. Ferrods, resistors, capacitors, relays, and filters are examples of equipment that may be restorable. Ferrods should be washed for at least 20 minutes for best results. Water may be found in the capacitors between the can and plastic cover and should be removed. Relays and relay covers should be cleaned to prevent future contact troubles. Chokes should be dried with hot air blowers or hair dryers (130°F maximum temperature) to eliminate leakage to ground. Resistance readings should be taken on all relays, capacitors, and chokes affected by water damage to determine the extent of leakage to ground.

2.46 All 6A memory modules affected by flood waters should be unplugged and replaced even though serious electrolytic corrosion may not be present. 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 them. This would be impossible to do in the field and necessitates replacement. 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 damaging the ferrite sheets or breaking additional wires due to the force of the water. Careful washing under frames may be needed 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. 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.

> ***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 as irreparable damage may be done to either the memory or the loader.

> ***Caution: Removing cards by hand may destroy the programs written on the cards.***

2.48 All flooded memory modules should be replaced as soon as possible, as 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 due to "back in service requirements", but 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 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 3 days, but will vary due to actual conditions.

Circuit Packs

2.50 Circuit packs without serious corrosion may be reused after cleaning and testing. All circuit packs affected by flood waters 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 source for future troubles as circuit packs are removed and replaced.

2.51 The contact surfaces of all circuit packs should be cleaned with KS-7860 petroleum spirits and a KS-2423 or equivalent lint-free cloth. Only approved noncorrosive and nonfilming solvents should be used to clean the contact surfaces, as other solvents might damage the circuit pack. Abrasive substances, such as erasers, should never be used for cleaning contact surfaces. After cleaning, KS-19416 L2 lubricant shall be applied to the contact finish. Apply solvents and lubricants to contact surface with a brush.

> ***Caution: Do not use dip method.***

The board should be positioned with the contact paths down to allow excess lubricant to drain off. Contact surfaces should never be touched with the fingers. Clean body of circuit pack with a dry KS-2423 or equivalent lint-free cloth.

3. REMEDIAL ACTION AFTER WATER DAMAGE TO POWER PLANT EQUIPMENT

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

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

3.03 Oil and grease should be removed with some commercial solvent such as KS-7860 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. Therefore, a fire extinguisher should be accessible at all times.***

3.04 The fumes of nearly any cleaning solvent can cause suffocation. The fumes of some may cause sickness if in sufficient concentration for a sufficient length of time. Therefore, it is important that good ventilation be maintained while using any cleaning solvents.

3.05 It is particularly desirable that ball and roller bearings be cleaned and repacked as soon as possible. The balls or rollers are highly subject to corrosion and if not cleaned within a day or two after the water subsides, they will probably have to be replaced.

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

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

3.08 After cleaning, all parts subject to rust should be coated immediately with oil unless they are completely covered with a protective paint or finish.

Insulation Resistance

3.09 Before putting apparatus back in service or connecting power, it is desirable that the insulation resistance of all coils to frame should increase to at least the value shown by the lower curve in Fig. 4, and it is desirable to raise the resistance closer to the upper curve. A figure of 1 megohm (1,000,000 ohms) at the normal operating temperature of the machine is generally considered the minimum value but, as indicated by the curve, a high temperature at the time of reading may make it unnecessary to reach such a high value. For determining the final drying condition, constancy of insulation resistances values taken at, for example, 1- or 2-hour intervals is more important than the actual values reached. Some telephone power plant apparatus can be dried out sufficiently in 24 hours of heating, as covered herein, and practically all of it can be dried in 72 hours. Machines have been reconnected satisfactorily without any drying but if at all possible some drying should take place. Since the insulation resistance cold is much greater than hot, if a machine is put in service without any drying, the resistance will drop fast as it heats up and the insulation may fail in a few minutes. Even an hour at a high temperature with good circulation may mean the difference between successful operation and failure when voltage is applied. It is also highly desirable to run a machine at reduced voltage and no load for a while if possible.

3.10 The methods of measuring insulation resistance most likely to be feasible in emergencies are by a KS-20538 Volt-Ohm-Milliammeter or equivalent, Wheatstone Bridge, or other 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 terminals, etc, should be inspected to see that braid is not damp enough or close enough to the metal to provide a surface path to frame.

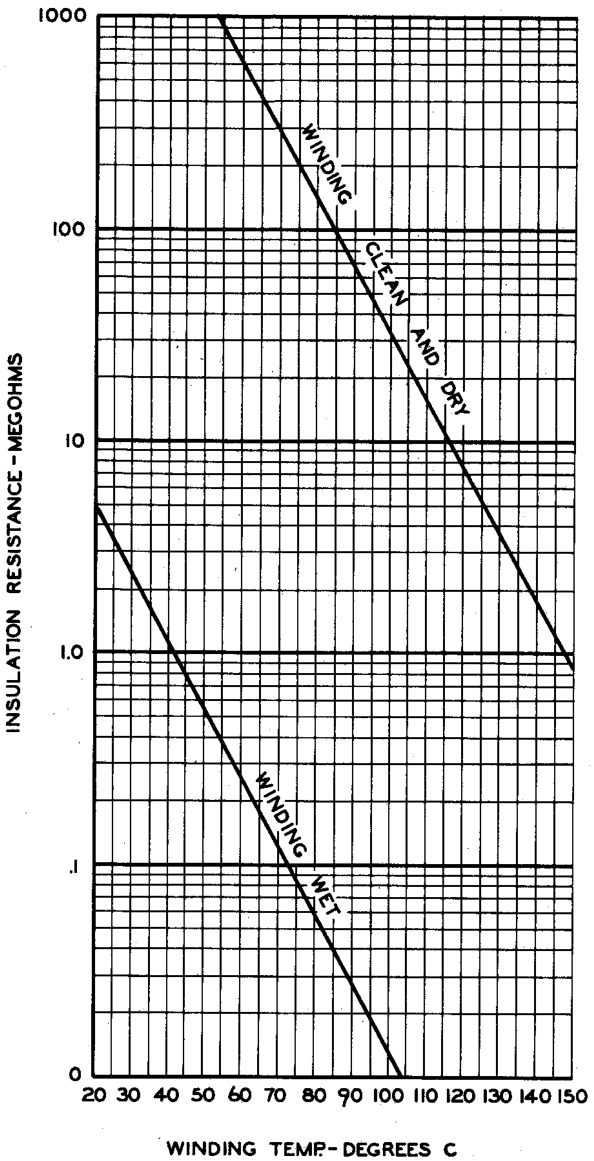


Fig. 4—Insulation Resistance of Induction Motors

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

Drying by External Heat

3.12 The drying procedures using external heat are given in 2.12 through 2.29. 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 in which the general humidity is kept low.

3.13 If it is at all possible that water has been trapped inside, the apparatus should be turned or shifted occasionally to allow it to run out. The submersion of apparatus while warm will sometimes create a vacuum that draws in water. The drilling of small drain holes will sometimes be the best means of removing the water.

Drying by Internal Heat

3.14 If current is passed through the windings (Fig. 5, 6, and 7) the heat internally generated will assist in the drying operation. This method is often faster than 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 85C (185F). The temperature measured by thermometer on the outside of the windings should never exceed 65C (149F) 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, the regular engine-driven reserve generators or electric-welding generators may be used as a source of low-voltage direct current for internal heating and the regular engine-driven reserve alternators may be used for alternating current.

3.16 Air circulation hastens the drying action where internal heat is applied just as it does where external heat is applied.

Drying by Internal and External Heat

3.17 Drying by a combination of both 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 internal heat only. Temperatures should be taken frequently by the resistance method and the method of controlling the temperature should be quick and positive. Generally speaking, this combination of methods requires more equipment and skilled

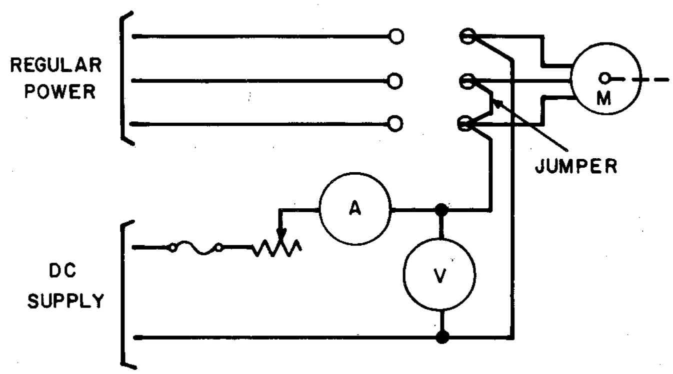


Fig. 5—Schematic For Drying a 3-Phase Machine While Stationary by Heating With Low-Voltage DC

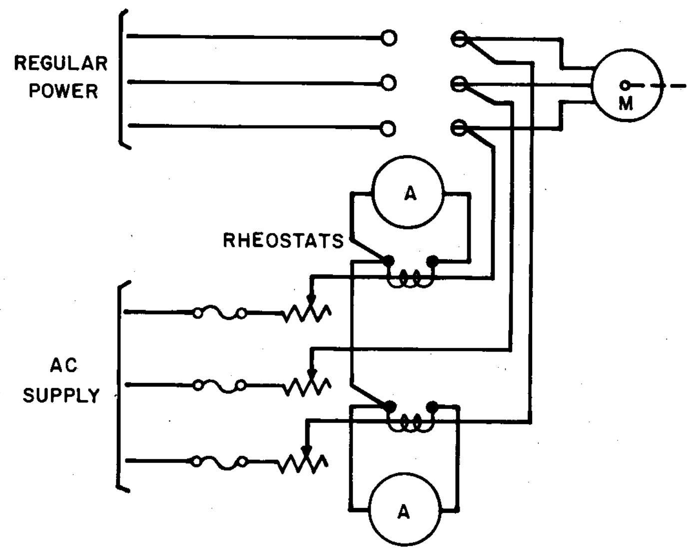


Fig. 6—Schematic for Drying a 3-Phase Machine While Stationary by Heating With Low Voltage AC

attention and is only justified where the time factor is very important.

Revarnishing of Coils

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

Fractional Horse Power Machines

3.19 In addition to the general drying information already given, 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, small inverted converters, etc, are small enough to allow complete disassembly and removal to an electric oven. If the surface is small enough and the stream of hot air is sufficient, it may even be feasible to dry panel equipment by directing hot air against it. In general, it

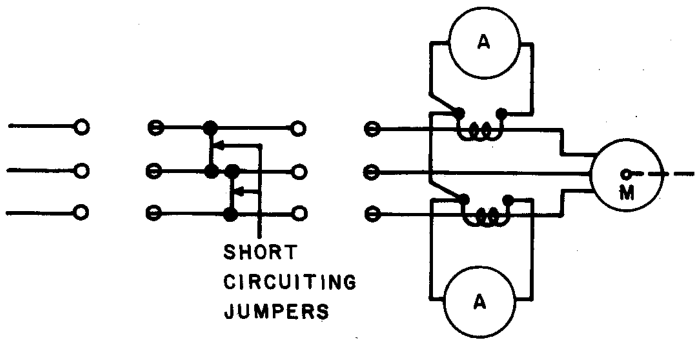


Fig. 7—Schematic for Drying Rotor of 3-Phase Synchronous Motor by Short-Circuiting the Terminals and Rotating Slowly by External Force With Low Excitation

should not be necessary to dry these small machines with internal heat.

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 difficult to remove. When the set is running, internal water will usually be thrown out by centrifugal action 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. In order to dry the commutator, hot compressed air may be forced in or the surface may be heated with strip heaters wrapped around the surface. Space heaters clamped to the surface or some other source of heat set under the commutator are additional means of drying. All these methods must be watched carefully since a temperature over 100C (212F) may soften the mica binder. An open flame should never be applied directly to the commutator.

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 in order to hold the current down to full-load value, but usually no harmful current will flow with ordinary excitation. If the machine has a series field winding, it should be reversed so that residual will not start a build-up that will carry beyond the full-load mark. If there is any doubt about it, it may be well to 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 per cent of normal. This voltage should be adjusted as necessary to limit the stator and rotor temperatures to 85C (185F) read by resistance, or 65C (149F) 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, paper wrappings, etc, may swell and warp sufficiently to justify or require 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 particularly apply to such points as rheostat bearings, contactor bearings, knife edge or pencil bearings in power-type relays, current-carrying contacts, etc.

3.26 Cartridge fuses that have been water damaged should be replaced if an adequate supply is available. If it is not, then the fuses should be removed from the clips and cleaned. If the fuse element is not open and the ferrules are reasonably tight on the barrel, a thorough drying should make them again ready for service.

3.27 Circuit breakers with the exception of molded case type, may be disassembled, cleaned, and dried satisfactorily except that the potential coil and series coil (if wound with small wire) and any fiber parts and springs may have to be replaced.

3.28 The autotransformer-type compensators may be disassembled, cleaned, and dried satisfactorily. If of the oil immersed switch-type, fresh oil should be added after the oil immersed parts have been cleaned.

3.29 The resistance type (KS-5309) compensators may be reconditioned except that the carbon pile resistance units will probably have to be replaced.

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

3.31 Panels may be cleaned with a hose. Slate may then be wiped off with one of the solvents covered in 3.03 and then oiled with the oil normally used for panel maintenance. Asbestos panels, after washing, should be wiped with one of the solvents.

3.32 Western Electric Company telephone-type relays, or any other type having coils which have not been impregnated, should be discarded. In cases of necessity, some of them may be found usable for a time after drying but the small percentage, together with the almost certain drastic decrease in life, makes it advisable to plan complete replacement.

3.33 In general, voltage and voltmeter relays that have been water damaged should be replaced.

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

3.35 Transformers and inductors will likely 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, even nonimpregnated coils may be sufficient reconditioned to give service for a time.

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

3.37 Voltage regulators similar to the cam type may be disassembled, cleaned, and dried satisfactorily except that the Warren cam-driving motor and the rectifier may have to be replaced.

Open Wiring

3.38 The stitching on all local forms should be cut and the leads separated so they can be dried.

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

3.40 Wiring and varnished cambric insulation should be replaced. Varnished cambric tape on bus bars should be replaced.

Wiring In Conduit

3.41 Wire that is not rubber or PVC covered insulation cannot be dried satisfactorily in a reasonable time while in conduit. It should be replaced.

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

3.43 If leads are removed, the conduit should be flushed out, 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

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

3.45 Lead covered, rubber covered, and flexible steel covered cable may frequently be re-used. There is little that can be done to dry such cables except from within. If low voltage, high-current power is available, the leads 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 one megohm, the leads should be replaced.

Batteries and Counter EMF Cells

3.46 Batteries, especially those of the sealed type, are seldom seriously harmed by being submerged. The high specific gravity of the electrolyte keeps it from mixing with water if no charge is given. After the water has receded and the room and equipment have been thoroughly cleaned, the electrolyte should be siphoned off for a distance of an inch or so below the low electrolyte level line, the siphon nozzle being held always very near the surface so that the liquid removed is water rather than electrolyte. Open cells are much more likely to collect foreign matter in harmful quantities and particular attention should be given to this point, especially if the cell covers have been broken or displaced.

3.47 After cleaning and siphoning have been completed, the cells should be filled with electrolyte soon enough to prevent any of the plates being exposed longer than approximately 20 minutes. The batteries should then be given an equalizing charge as soon as possible. The electrolyte should be analyzed by the battery company at the first opportunity to see whether a complete replacement of the electrolyte is advisable.

3.48 Recharge the existing batteries after flood waters subside by using portable dc engine generators, rectifiers, or possibly welding machines. Where the total voltage of the battery, e.g., 130 replacement of the battery may be the faster and more reliable procedure.

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

3.51 Before locating a replacing battery, particularly on an upper floor, the floor strength should be considered. Approval of the building engineer should be secured before placing the cells.

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

3.53 Counter EMF cells should be emptied, washed out thoroughly with clean water, and refilled with new solution and oil.

Rectifiers

3.54 Semiconductor-type rectifiers may usually be cleaned and dried satisfactorily. The controlling relays should be throughly dried and cleaned. Some of the transformers may not be totally inpregnated. If these transformers are not dried throughly, a heat problem may develop.

3.55 Tube rectifiers may usually be disassembled, cleaned, and dried satisfactorily.

3.56 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 is still not sufficient, the rectifying element should be replaced.

3.57 Selenium rectifiers:

(1) Wash down with clear water.

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

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

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

(5) Connect ac for a 10-minute period without dc load.

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

Transformers

3.58 Transformers in telephone offices are usually of the instrument type or of the small air cooled power type and may be satisfactorily dried with external heat following the precautions listed herein. A combination of internal and external heat will also prove to be effective. Low-voltage direct current may be put through up to the rating of the windings, or one winding may be short-circuited and the other excited sufficiently to cause a current not exceeding full load to pass through the secondary. For normal frequency, the primary voltage for this arrangement will be very low, possibly in the order of 1 percent to 2 percent of normal.

3.59 Oil-cooled transformers will usually be reconditioned by the power company. However, they may be emptied of liquid, cleaned out, 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 85C to 90C (185F to 194F), read by the resistance method. Probably about 20 or 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

3.60 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 batteries. Also disconnect the AC source to rectifiers used to charge these batteries.

(2) Hose down those sections of the engine, alternator, and controls which were below the high water mark. Avoid directing the hose such as to add water to 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 proceed to (4) below.

(4) Remove oil dipstick from 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 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 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 direction of rotation until engine binds and then again rotate the engine in the normal direction. Continue the above procedure until two rotations without binding are accomplished.

(7) If water was observed in (5) or binding occurred in (6) above, redrain oil crankcase and refill 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 engine protection circuits are operative.

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

(10) When the alternator windings are dry (see Fig. 1), remove the short from the exciter field and place the alternator set in 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 procedures (1) through (3) above for diesel engine alternators.

(2) Clean out compressor air intake duct system.

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

(4) Remove the oil dipstick from the engine and determine if 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 (8) above for diesel engine driven alternators.

(6) If water was observed in (3) or (4) above, purge crank (no fuel injection—no ignition) the engine for 20 seconds. Then redrain oil sump and replace oil filters. Refill 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 in this manner to expedite drying of the alternator.

(8) Proceed with (10) and (11) above for diesel engine driven alternators.

Electrolytic Capacitors

3.63 Dry-type electrolytic capacitors will probably be re-usable. There may, however, be cases where cooling has created a vacuum strong enough to draw in water that will cause failure (and subsequent need for replacement) within a few days.