PART TWO
EXTERIOR SYSTEMS

CHAPTER 5
OUTDOOR SUBSTATIONS

5–1. Substation work

Safety precautions to be used in maintaining electrical apparatus and lines found in those outdoor areas must be observed.

5–2. System familiarity

A substation provides a protected area where equipment and lines permit switching power circuits and may allow transforming power from one voltage to another. A substation presents a potential safety hazard because usually only portions of the apparatus concerned can normally be de-energized. For safe operation, a thorough knowledge of the system, including aerial and underground line connections, is necessary. Systems are designed to be safe to operate if maintained properly. Operating safely requires maintenance to be done in a manner that eliminates risks and requires knowledge of the work area, its hazards, and its design operating rationale.

a. Diagrams and schematics. Electrical diagrams and schematics of the substations should be available at the facility's engineering office and should be updated. Diagrams and schematics should be studied to understand the operation of the systems and the location and connections of all circuits. Protective devices, alarms, and interlocking circuits all operate to protect the system. The worker must understand where, why, how, and when blocking protective devices will maintain safe working conditions. However, only a supervisor can authorize blocking.

b. Engineering guidance. Diagrams and schematics should be kept up to date under the supervision of the facility's engineering staff. Staff guidance should be sought when performing maintenance on complex systems. Staff input is mandatory if the maintenance work involves additions or changes to the power and control systems involved.

c. System operation. System single line diagrams should be permanently mounted at each substation. When Safe Clearance switching operations are performed, mimic buses on switchgear are helpful as a visual indication of the lines or equipment served.

(1) *Protective devices.* Protective devices within the system, such as relays and fuses which are to be worked on or replaced, must retain respectively their correct coordination settings or be of the proper size and type. Always record previous data so that changes in system coordination are not made.

(2) Alarms. System alarms, if blocked during maintenance, must be returned to their correct operating conditions.

(3) *Interlocking.* Interlocking is provided to maintain proper electrical operation in the case of a circuit loss or switching change. Interlocking provisions should be known so as to eliminate any dangers of electrical feedback from another source. Possible paralleling of two unsyschronized sources. Or other unsafe operation.

d. Abnormal conditions. Any maintenance done after fault conditions have interrupted normal service, imposes more than normal maintenance risks. Faulty energized equipment and lines should always be de-energized before any work is done. All abnormal operating equipment and electrical components should be de-energized and tagged.

e. Defective equipment. If an apparatus which is to be worked on is found to be in a dangerous condition or not working properly, it should be removed from service immediately and tagged. Then, a complete report of the condition of the equipment should be provided by the worker to his/her foreman or supervisor the same day.

(1) Defective equipment removed from service, such as distribution, potential, and current transformers; capacitors; and surge (lightning) arresters must positively be identified by the foreman before they are put in storage. Any existing defective equipment in storage or at any other location must also be identified.

(2) Identify defective equipment by painting a large red X on the body, not on the top of the equipment. The red X must remain on such equipment until it has been repaired or until it has been prop-

erly disposed of.

(3) It should be considered gross neglect of duty and willful disobedience of instructions for a worker to deface in any way the red X on defective equipment or to place such equipment in service while so identified. The worker in charge of repairing any piece of defective equipment should be the only person authorized to remove such identification and then only after all repairs have been made and the equipment has met all necessary tests.

(4) In cases where defective or reclaimed equipment is repaired and tested by electrical facility workers, they may then remove the defective identification marking.

5–3. Work area control

Control of the work area is mandatory to accident prevention. Procedures for specific maintenance may vary but certain rules are basic to all work.

a. Previsit briefing. A previsit briefing will be carried out to familiarize workers with the work area. The briefing will include the status of the equipment, what part if any is energized, location of ground, what the limits of the working space are, what open switches disconnect the equipment from any source of supply, and system operating aspects. If for any reason there is an interruption in the work, or conditions change, another conference briefing will be conducted to familiarize all of the workers with the new conditions.

b. Clearance access. When entering an attended station, workers not regularly employed in the station must report immediately tot he operator in charge, stating their names, offices, purpose of the visit, and their planned activities. For unattended stations, workers must be escorted by installation personnel. Unattended station doors must always be kept closed and locked.

c. De-energizing work areas. When it is necessary to work on or near any electrical circuits or apparatus, the Safe Clearance procedures prescribed in paragraph 3–8, as well as pertinent rules given in this chapter, must be carefully followed. If work must be performed on energized lines, it is mandatory that the requirements given in paragraph 3–12, be followed.

(1) *Switching.* Station operators must notify maintenance workers before doing any switching that affects their work.

(2) *Lockout and tagout.* Lockout and tagout all power sources and circuits to and from the equipment and circuits in the work area. All controls will be made nonoperative and all feedback circuits, such as from potential transformers or other sources, will be cleared.

(3) *Barriers and barricade tape.* Temporary barriers will be placed between the space occupied by workers and the energized equipment, both as a protection and a reminder of the limits of the working space. The person holding the Safe Clearance is responsible for barricade locations and they are to be moved only under that person's direction. After the work is finished, that person will remove the barriers prior to releasing the Safe clearance.

(a) Use of barricade tape. It is recommended that solid red barricade tape be used to enclose work areas and a white-with-a-red-stripe barricade tape be used to isolate temporary hazard areas. Only active workers may enter the solid red taped area until the hazard has been corrected. A temporary hazard could be a faulty but energized line.

(b) Placement of barricade tape. Tape should completely enclose the work area, be visible from all approach areas, and be at an effective barrier level. The area enclosed should be large enough to provide worker safety and arranged so any test equipment can be operated outside the taped area.

(c) Nonpermittted use. Temporary barriers and barricade tape will not be used as a substitute for guard railings, for work platforms, or for protection for holes in the floor. Information tags or other warning devices will be provided to identify a hazard that is not obvious.

(4) De-energizing proof testing. All lines and equipment on which de-energized work is to be performed will be tested to be sure they are de-energized before protective grounds are applied.

(5) *Grounding.* After indication that all circuitry in the work area is de-energized, provide protective grounds as covered in paragraph 3–11. Place ground so that each ground is readily visible to at least one member of the crew. Stay clear of cables and connecting devices while ground are being applied.

(6) *Adjacent energized equipment protection.* When work is to be done on or near energized lines, all energized and grounded conductors or guy wires within reach of any part of a worker's body will be covered with rubber protective equip-

ment. Bare communications conductors will be treated as energized lines and will be protected accordingly.

(a) Flexible blankets will not be used at grade level without protecting them from physical damage and moisture by means of a tarpaulin, canvas, or protective mat.

(b) To avoid corona and ozone damage, rubber protective equipment will not be allowed to remain in place on energized lines or apparatus overnight or for more than one 8-hour period, unless approved by the supervisor in charge.

(7) *Worker protection*. Personal protective apparel will be worn as deemed necessary be the supervisor or foreman in charge, as recommended by the manufacturer for the tool being used, or as otherwise directed in this manual. Protective tools will be used as appropriate to the work being done.

d. Working area housekeeping checks. Check the working area to ensure safe conditions and eliminate or protect against such hazards which can include the following—

(1) Equipment hazards such as lack of guards or safety devices.

(2) Material hazards such as sharp, worn, slippery, corroded, or rough items or areas.

(3) Work station weather hazards such as wind, rain, ice, or dust.

(4) Arrangement hazards such as congestion, unsafe storage in place, or improper worker's tool provisions and storage.

(5) Lack of fire prevention and first aid equipment and inadequate working equipment and tools.

(6) Insufficient testing equipment, protective apparel and equipment, and safety forms and tags.

e. Installation precaution. All apparatus and lines should be legibly marked for identification and to match diagrams and schematics before any work is done. Markings should not be placed on removable parts. Where permanent markings are not provided, temporary markings may be utilized on the understanding that follow-up permanent markings will be provided for all devices and circuits operation at voltage levels above those used for control circuitry.

5–4. Safety rules checklist

The following minimum requirements are mandatory to ensure worker or equipment safety:

a. Communication channel availability. Some method of communication to summon emergency personnel or medical assistance will be provided and will be functional through the period which work is performed.

b. Lighting level. The lighting level will be sufficient for safe work. Temporary self-contained lighting systems will be provided where normal natural or installed lighting is not sufficient, available, or safe.

c. Working period. Normally no worker will work more than a standard 8-hour period with suitable breaks. Under emergency conditions a maximum of 12 hours may be necessary but the work period will be preceded and followed by a minimum of 8 hours off.

d. Technical direction. On all cases of specialized work a qualified person will provide technical direction.

e. Co-worker requirement. No one will work alone.

f. Worker qualification. Workers must be qualified to do the work in question; must be fully cognizant of all safety procedures and equipment conditions; and must be alert and in good health.

g. Equipment preparation. In addition to previous requirements of this chapter check the following:

(1) All control power must be de-energized and all stored-energy mechanisms must have been discharged.

(2) All stationary (bolted or plug-in) nondrawout type circuit breakers must be de-energized on both the line and load side.

(3) All drawout circuit breakers must be checked to be sure that interlocks (which prevent the circuit breaker from being withdrawn in the closed position) have not been defeated or bypassed.

5–5. Testing safety rules

When performing electrical tests at any voltage the person in charge of the testing must, in addition to other applicable instructions in this manual, take the following precautions:

a. Use only devices which have been checked and found to be properly calibrated both immediately before and immediately after the test.

(1) When testing live circuits or equipment, all temporary leads used in testing must be securely supported to prevent interference with other workers or injury to the tester.

(2) Protect testing personnel and others, particularly their eyes, from flashovers.

b. When performing mechanical tests, keep the operating personnel and others at a safe distance, or in a safe location by means of barricades, to prevent injury resulting from the failure of the equipment being tested.

c. Use an approved voltage detector when testing for blown fuses on low-voltage circuits. Do not use fingers as the test for blown fuses.

d. A test indicating absence of voltage on the secondary side of a transformer or regulator must not be considered as a positive indication of the absence of voltage on the primary side.

e. When it is necessary to test transformers and other equipment for short circuits, open circuits, and grounds, and a step-up test transformer is used, the following procedure must be followed:

(1) In the low-voltage circuit of the step-up transformer, use fuses rated not larger than 10 amperes unless large equipment is being tested. Control the circuit with a double-pole switch, so that all wires feeding the step-up transformer will be de-energized when the switch is open. The medium-voltage leads from the test transformer to the apparatus being tested must be kept insulated from the surface on which test personnel are standing. The medium-voltage wire to be handled during the test must be attached to the end of a 6-foot (1.8-meter) live-line safety tool, and personnel handling the tool must hold it near the opposite end.

(2) in testing large transformers, use a testing transformer and fuses large enough to handle the charging current of the transformer being tested.

(3) Workers are positively prohibited from handling live medium-voltage wires with their hands. The step-up transformer circuit must be de-energized each time it is necessary to handle the wires for making connections incidental to the test, unless the wire is attached to the insulating stick.

5–6. Switching safety rules

Opening/closing a power switch may expose the operator to some degrees of hazard. An accident may occur if a switch is closed when a fault is still present on the line. The supervisor, before writing the switching orders, must prepare the switching sequence and all load isolation requirements. All switches operated in the switching sequence must be correctly identified and the instruction manuals of the switches must be provided. The worker must read the instruction manual to be familiar with the switch operation. All safety steps listed in he instruction manual must be scrupulously followed before opening/closing a switch.

a. Air switches. Most switches today are air switches. Many switches cannot be opened if there is a load on the line, if there is a large transformer magnetizing current from transformer, or if there is a heavy charging current from an unloaded transmission line. Always know the interrupting capabilities of the switch you are opening or closing.

(1) *Disconnect switches.* Disconnect switches of the nonload break type will not be used to interrupt loads and magnetizing currents, unless specific approval has been given that the disconnect will interrupt the current safely or unless the switch is of the loadbreak type. Switch sticks providing the minimum working and clear hot stick distance are used to manually operate switches and they should be used for no other purpose. Always assume that disconnect switches are not of the load break type, unless you have positive proof otherwise and then operate on the following basis:

(a) Disconnect switches may be used with care to open a live line, but not under load.

(b) Disconnect switches may be used with caution to open sections of de-energized lines, where these lines parallel other medium- or high-voltage lines. Under certain conditions induced voltages can build up in the de-energized line and can be dangerous to switching operations.

(c) Be aware of dangers when using disconnect switches to open a tie line or to break two parallel medium- or high-voltage lines.

(2) *Airbreak switches.* Gang-operated airbreak switches equipped with arcing horns may be suitable for loadbreak operation, or they may be only capable of interrupting the magnetizing current of transformers, the charging current of lines, or to make and break line parallels. Airbreak switch use

should be specifically stated. The handle of the switch should be of the permanently insulated type and be effectively grounded when operated. Ground mats should be provided for the operator to stand on with both feet. Either fixed or portable small iron-mesh mats should be used. The mats must be electrically connected to the operating rod and the substation ground grid to equalize the ground gradient and prevent any potential differences in case of insulation failure or flashover. Rubber gloves should be worn by the operator.

(a) The hinges of airbreak switches should be sufficiently stiff (and kept in this condition) so that when the blades have been turned into the open position they will not accidentally fall back on their line-side energized clips.

(b) The switch should be inspected after it has been opened to see that all blades have opened the proper distance. Single-throw airbreak switches should be opened to the maximum amount. Double-throw airbreak switches should be opened so that the blades clear both sides of the switch by the same amount.

(c) Locks will be provided for all airbreak switch operating mechanisms and they will always be kept locked, except when opening or closing the switch.

(3) *Interrupter switches.* Interrupter switches are designed to be opened under load. Metal-enclosed loadbreak switches are used in place of circuit breakers as a more economical switching method.

(4) *Inching.* Inching is a method of opening manually-operated nonloadbreak disconnects in a gradual manner, when the operator believes there is no load current. If a small arc occurs from the charging current, it may be considered that a cautions opening would allow the arc to be broken. Inching is dangerous and this practice is prohibited.

b. Oil switches. The consequences of operating a faulty oil switch or closing into a faulted circuit with a oil switch are likely to be devastating and possibly fatal. Switching procedures must be developed at each facility to make sure that no energized oil switch is operated while workers are in the vicinity. Unless the switch has been equipped to operate from a remote location at least 20 feet (6 meters) away, the switch must be completely de-energized before switching. Switch position and ground conditions must be verified before operation. In addition, no medium-voltage oil switch is to be operated unless routine maintenance, including oil testing, has been performed within the past year. Oil switches must incorporate a mechanical stop to prevent inadvertent operation ground. Any abnormalities or defects discovered in any oil switch should be reported to the supervisor.

c. Similar switching section. When switch bays, cells, or compartments are similar to adjacent sections, the separation barrier between sections must be painted an appropriate color to prevent the possibility of pulling the wrong blade.

5–7. Fusing safety rules

Always remember that a fuse is a single-phase device. Fuses can be subject to partial melting or damage by currents which may not be of sufficient magnitude to blow the fuse.

a. Fuse handling. Fuses should normally not be handled, except when they need to be replaced. Remove them completely and as speedily as possible. When replacing fuses in primary fuse cut-outs, do not use your free arm to shield your eyes from possible flashes. Always use safety glasses. The person changing the fuses must stand firmly on a level surface and, where operating in an elevated position be secured with a safety belt to prevent a slip and fall if there is a flash. Fuse sticks must be used in all instances.

b. Operation of energized fuses. Open all lines protected with energized fuses in the same manner as for air switches. De-energize nonloadbreak installations. For loadbreak installations provide a time delay after fuse replacement, in order to allow the fuse to interrupt any fault condition that was not corrected at the time of the fuse replacement.

c. Open fuse holder. Do not leave outdoor fuse holders open for an extended period of time, as water damage or warpage from the elements may make closing them dangerous or degrade their protective ability.

d. Closed-position fuse locking. Follow the fuse and or switch manufacturer's instructions, as appropriate, to be sure that the fuse is securely locked, latched, and held fast in a closed position.

e. Bypassing. Do not bridge fuses or fuse cut-outs internally. Where it is necessary to bypass fused conductors, use plainly visible external jumpers and remove them as soon as possible.

5–8. Energy-storing protective device safety rules

Protective devices such as surge arresters, choke coils, and capacitors store electrical charges as a by-product of their protective mechanism. This stored charge must be discharged to ground before such devices can be considered de-energized. Always wear eye protection when de-energizing or energizing these devices.

a. Surge arresters. A surge arrester limits over voltages and bypasses the related current surge to a ground system which absorbs most of the energy. The overvoltage condition can be caused by a fault in the electrical system, a lightning strike, or a surge voltage caused by switching loads. All surge arrester equipment must be considered as loaded to full circuit potential, unless it is positively disconnected from the circuit. Be sure the permanent ground conductor is intact before any work is done.

(1) High-voltage substation or at grade surge arresters should always be provided with screens or fences to prevent possible contact while parts of the surge arresters may be alive. The screen or fence should have a gate large enough to permit the removal of individual units. The gate should be provided with a lock and the key should be kept by an authorized person.

(2) Surge arresters must never be touched or approached, unless they are completely disconnected from all line lines and live equipment and until all parts have been discharged to ground and effectively grounded.

(3) Horn gap switches must be opened and separated from all live lines and equipment, whenever it is necessary to work near a surge arrester.

(4) If the first attempt to disconnect a surge arrester is unsuccessful, wait 2 or 3 minutes before making a further attempt so as not to cause an internal fault.

b. Choke coils. Choke coils are inductors which operate in a manner similar to surge arresters, except that they operate on overfrequency rather than overvoltage.

c. Capacitors. Capacitors consist of an electrical condenser housed in a suitable container. Power capacitors provide for power factor correction. Coupling capacitors are used for coupling communication circuits to metering circuits. Because capacitors can hold their charge, they are not electrically dead immediately after being disconnected from an energized line. Capacitors on electric lines should be provided with discharge devices for draining the electrical charge to 50 volts or less in 5 minutes, after the capacitors on electric lines should be provided with discharge devices for draining the electrical charge to 50 volts or less in 5 minutes, after the capacitors have been completely disconnected from the circuit.

(1) *Discharge circuits.* The operation of these units must not be depended upon for safety, since they may be burned out or not functioning as designed. Line capacitors removed from service from any purpose must be considered at full voltage or higher until the terminals have been short circuited and discharged to ground by approved method. Do not short circuit terminals until capacitors have been de-energized for at least 5 minutes. Capacitors made before 1979 usually contain PCBs. Precautions listed in paragraph 3–4 on the handling of hazardous materials must be followed if the case is ruptured or liquid is visible on the outside of the case.

(a) It is not safe to use fuses or disconnect switches to disconnect large capacitor banks or 60 kilovolt-reactive single-phase, 180 kilovolt-reactive three-phase, and larger. Circuit breaker must be used.

(b) After disconnecting all capacitor banks, wait 5 minutes. Short-circuit and ground all terminals. All operations must be performed using rubber gloves or a hot stick. On eye-connected banks, the neutral may or not be floating. In either case, it must be grounded.

(c) Safe practice requires that the ground and short-circuit placed on capacitors be left on until work has been completed. When working on or testing capacitors in the shop, the work area must be barricaded as a safety measure for other workers.

(2) *Coupling Capacitors:* A little known characteristic of coupling capacitors makes them especially hazardous to personnel if not properly grounded. This characteristic is their extremely high resistance, which results in a long discharge period.

(a) During shipping or storage a coupling capacitor must always have a shorting wire.

(b) During maintenance, a grounding wire must be connected to each exposed metal terminal that anyone can contact. Grounding wires must be left in place for the entire duration of maintenance to ensure discharge.

5–9. Instrument transformer safety rules

Instrument transformers reproduce a primary cir-

cuit voltage or current in a low-voltage secondary circuit for use in metering or relaying the primary circuit.

a. Voltage (potential) transformers. These units provide a means of obtaining low voltage from a higher voltage circuit. To serve their intended purpose they must be designed and selected within certain accuracy limits and burdens. Units procured as replacements must have characteristics identical with the original units. There are certain hazards inherent in the maintenance and removal of these units. A voltage transformer has a constant voltage maintained on both the primary and secondary, although there is a fixed difference between the two voltages. If by accident the secondary is short circuited, a very high current will flow in both windings, causing the windings to overheat very quickly. The case and one of the windings of the low-voltage side of voltage transformers will be grounded before energizing the transformer.

(1) Replacing a blown primary-winging fuse is potentially dangerous when the circuit to the transformer is energized. The secondary fuses must be removed to prevent the possibility of energizing the voltage transformer from the secondary side. A thorough investigation must be made in either case to determine the probable cause of the trouble, before attempting to install a new primary-winding fuse. Ordinarily, trouble in the transformer is apparent from visual evidence in the form of a smoked or burned case, damaged bushing, or the condition of the fuse. Also, before any inspection or replacement is done, be sure the service to the primary side of the voltage transformer is disconnected. A dark lamp, connected on the low-voltage side of a voltage transformer, is not a positive indication of the condition of the high voltage side. Voltmeters, in addition to lamps, must be connected to the low-voltage side. Lamps must first be connected while the voltmeter is used as an extra check. On most modern switchgear a drawout arrangement usually automatically disconnects and ground the transformers, when access to the fuses is necessary.

(2) A supervisor should give instructions for replacing a blown primary winding fuse on a distribution voltage transformer located within switchgear, or where it is impossible to use a standard 6-foot (1.8-meter) puller.

(3) Whenever a circuit breaker or a sectionalizing switch is not provided to isolate the voltage transformer, the worker must report the situation to his/her supervisor immediately. The supervisor must arrange for a feeder breaker opening. Replacing primary fuses when the transformer is energized is not authorized.

b. Current transformers. These units provide a method of obtaining a lower amperage at a low-voltage from a higher-voltage circuit. Current transformer cases and secondaries will be grounded before energizing any current transformer. The main risk involved with the maintenance of current transformers occurs when the secondary side is unintentionally opened while the primary side is energized. Opening the secondary side causes a very high voltage to be set up in the secondary winding, which stresses the insulation an presents a serious personnel hazard. The secondary circuit of a current transformer must not be opened while the primary side is energized. Before opening the secondary circuits of any current transformer, the secondary leads must be short-circuited and grounded at some point between the current transformer and the location at which the secondary circuit is to be opened.

5–10. Power transformer and regulator safety rules

Power transformers change voltage levels. Voltage regulators apply needed control for variation s in loads whose effect on line-voltage drop exceeds that which is acceptable. Both require regular servicing but their protective and circuit disconnecting means are not necessarily similar. See paragraph 6–11 for additional power transformer safety requirements.

a. Transformers. Consider all transformers energized and at full voltage, unless they are disconnected from primary and secondary wires, or unless they are disconnected from the primary wires and then short circuited and grounded. The secondary neutral will be considered a sufficient ground, provided there is a grounding conductor which is interconnected with the common central, the transformer case, and a ground electrode. Always check continuity of this ground connection. When removing transformers, the case and neutral grounds must be disconnected last. Under no conditions will transformer covers or handhole plates be removed, nor will any work be done on the inside of transformers until these instructions have been complied with.

(1) When transformers are installed or replaced, the secondaries will be checked for correct voltage and, where applicable, for phase rotation.

(2) When transformers are installed, and before they are energized, the ground connection will first be made to the case and to the neutral when applicable.

(3) When working on or in the vicinity of any three-phase wye-connected transformer bank, check whether the transformer neutral is grounded. If not grounded then the neutral is floated and it is possible to have full phase-to-ground voltage on the neutral.

(4) Unless transformers are load-tap-changing (LTC) type, tap changers will be operated only when the transformer is de-energized. When re-energizing, maintain a safe distance of at least 20 feet (6 meters) to assure that internal switching was successful.

(5) When relieving pressure on transformers, the pipe plug, pressure relief device, or inspection cover place will be loosened slowly, so that the internal pressure of the transformer will dissipate gradually. Pressure relief valves will not be opened when there is precipitation or high humidity, except on failed transformers and when re-fusing.

(6) Transformers or tanks will not be entered unless forced ventilation or an air supply containing a minimum of 19.5 percent oxygen is present and maintained in the work area.

(7) Energized padmounted transformers and equipment will be locked or otherwise secured when unattended.

(8) Properly control connected leads or jumpers before transformers are raised, lowered, or repositioned.

b. Voltage regulators. Voltage regulators are installed with bypass and disconnect switches. Never open or close a regulator bypass switch, unless the regulator is set on its neutral position and the control switch is open, or automatic control is otherwise inactivated according to the manufacture's recommendations. When regulators are maintained as spares in substations, their bushings must be short-circuited and grounded.

5–11. Metalclad switchgear safety rules

Metalclad switchgear is inherently safe to maintain so long as manufacturer's instructions and the following rules are adhered to.

a. Prior to the drawout of a circuit breaker operating mechanism—

(1) De-energize switchgear (including control power) and ground as much of the switchgear as permitted by operating conditions.

(2) Trip the circuit breaker open and discharge the stored-energy mechanism if provided.

(3) Check that protective interlocks are functioning to protect against closed-position circuit breaker drawout.

(4) Assure that all crew members know you are racking out.

b. Maintenance can now be performed. Access to switchgear terminals through portholes in circuit breaker cells will be limited to the following—

(1) When both sets of portholes in a cell are de-energized, that is line and load or bus to bus.

(2) After both are de-energized, the access to switchgear terminals through the portholes will be permitted for cleaning, inspecting, and maintenance of terminals and bushings.

(3) Use an approved ground and test device for access to terminals. Such access may be for application of protective ground, phase identification on de-energized circuits, and phasing tests on live circuits. The use of a ground and test device positively and easily grounds the incoming cables and the switchgear bus. It also permits easy external connection points to the bus or cable for testing.

c. After providing required maintenance of the racked-out mechanism, the following precautions will be taken as a minimum:

(1) Check that the cubicle is free of foreign objects.

(2) Check that control circuits are de-energized by pulling fuses on control circuits.

(3) Ensure that the drawout mechanism is in the open position.

(4) Assure that all crew members are aware of that you are racking in.

(5) Close the cubicle door before closing the circuit breaker.

5–12. Network protector safety rules

A secondary network system provides a high degree of continuity of service in heavy-load density areas. A grid of interconnecting low-voltage cables is supplied by two or more medium-voltage feeders through transformers having secondary network protectors. Network protectors are used in large buildings with

heavy loads since the loss of one point of supply does not cause loss of service.

a. Closing. Do not close a network protector manually, unless specifically instructed to do so, and then only when it is certain that the medium-voltage feeder is in service and that the transformer is energized and in the proper phase relation. When closed by relay, the operation should be performed only by a worker properly qualified in maintenance of network protectors.

b. Maintenance safety.

(1) Always perform appropriate electrical tests using a three-phase network protector test kit, before performing any installation or operation of the network protector.

(2) Network protectors are designed to operate within the current and voltage limitations given on their nameplates. Do not apply these units to systems with currents and/or voltages exceeding these limits.

(3) To perform work on network protectors requires personnel with training an experience on energized equipment. Only qualified electrical workers, familiar with the construction and operation of such equipment and the hazards involved should be permitted to work on network protectors.

(4) There are several interlocks on a network protector for personnel and or equipment protection. Under no circumstances should they be made inoperative.

(5) Roll out the network protector's removable element before making any adjustments or doing maintenance of any nature.

(6) Never energize the network protector without its arc chutes and barriers in place.

(7) Always be sure that all network protector hardware is in place and bolted tightly before placing a network protector into its housing for operation.

(8) Since network protectors are used where a large amount of power is distributed to heavy-load density areas, a short circuit in the system involves very high fault currents. Extreme care should be exercised.

(9) The extensive use of barriers and interlocks as a part of the network protectors, provides greater safety to maintenance personnel. Keep barriers in place and immediately replace any that have been broken. Although barriers and interlocks are provided, insulated tools or insulated gloves are required to remove the rollout unit from the enclosure, and to remove fuses, or at the initial installation of the network protector on the system.

(10) Before performing maintenance or removing a network protector from service, de-energize the network protector.

c. After maintenance. On the first trial operation, or on the first operation of a network protector after repairs have been made on its mechanism or circuit breaker, the door of the network protector should be closed, when practicable. Always have a network protector blocked open, when installing or removing secondary fuses, to prevent the possibility of the network protector closing automatically.

5–13. Storage battery safety rules

Electric storage batteries emit hydrogen and oxygen, particularly while being charged. This forms a highly explosive mixture.

a. Smoking or the use of any open flame, such as torches, will not be permitted around batteries. When soldering or lead burning is done, the battery room must be well ventilated, the battery cell vent plugs must be removed, and the excess gas above the electrolyte must be blown out of those cells near the work area.

b. Cleaning batteries or terminals with brushes or other devices which may short out the cell will not be permitted. The ignition of the hydrogen-oxygen mixture in cells by a spark from a short on terminals has caused cells to explode.

c. When doing work on batteries where contact with the electrolyte can be made, a container with baking soda and water must be provided for workers to neutralize the electrolyte on hands and tools.

d. When making up electrolyte for storage batteries, a worker must always pour acid into the water. The reverse may cause an explosion.

e. Acidproof gloves, sleeves, aprons, and goggles should be worn by personnel while repairing batteries.

f. Do not store sulfuric acid in places where freezing temperatures can occur.

g. For further information on servicing and main-

taining storage batteries, see the manufacturer's instructions.

5–14. Safety requirements for phasing or connecting of circuits

Use phasing testers when it is desired to tie two or more circuits together. Never tie two circuits together without first checking their phase relations on all phases.