Report of Committee on Electrical Equipment Maintenance

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

The Committee on Electrical Equipment Maintenance presents for official adoption a partial amendment of NFPA 70B–1975, *Recommended Practice for Electrical Equipment Maintenance.* NFPA 70B–1975 is published in Volume 15 of the 1976 National Fire Codes and in separate pamphlet edition.

This report has been submitted to letter ballot of the Committee on Electrical Equipment Maintenance which consists of 26 voting members, of whom 21 have voted affirmatively, 4 have voted negatively (Messrs. Clement F. Baxter, W. L. McKeithan, K. W. Swain, J. Wells), and 1 did not return a ballot (J. L. Cadick).

Since this Committee reports to the Association through the National Electrical Code Correlating Committee, this report was also submitted to that committee which concurs with the submittal of the Report to the Association.

Amendments to the Recommended Practice for Electrical Equipment Maintenance

NFPA 70B–1975

1. Revise 1-2 as follows: Delete from second sentence: "are those operating at 15kV and below and . . ."

2. Revise 4-2.3.2 as follows: At the end of the first sentence add: "down to, and often including, the major items of utilization equipment."

In the second sentence add the word "power" *before the word* "system."

In the last line change "should" *to* "may."

3. Revise 4-2.6.4 as follows: Revise the second sentence and add two following sentences to read: ". . . such as drums, tanks and vessels should be operated at an appropriate low voltage from an isolating transformer or other isolated source. This voltage level is a function of the ambient condition in which the portable lighting is used. The aim is to limit the exposure of personnel to hazardous current levels by limiting the voltage." (*Last two sentences of present text remain.*)

4. Add a new Section 4-6 to read as follows:

4-6 Maintenance of Foreign-made Electrical Equipment.

4-6.1 Equipment of foreign manufacture poses some additional maintenance problems not usually associated with American-made equipment.

4-6.2 Quick delivery of replacement parts cannot be taken for granted. Suppliers should be identified, and the replacement parts problem should be reflected in the inplant spare parts inventory. In addition to considering possible slow delivery of replacement parts, knowledgeable outside sources of foreign maintenance engineering services should be established.

4-6.3 English-written parts catalogs, maintenance manuals, and drawings should be available. In contrast with literature and drawings developed by American manufacturers, these should not be automatically presumed to be understandable. Problems in translation should be identified as soon as literature is received, to ensure that material will be fully understood later when actual maintenance must be performed.

5. Revise 5-3.4 by adding a new second sentence to read:

"ANSI Standard Z244.1–1974 is suggested as a guide in developing an effective lockout/tagout for electrical and other energy sources."

6. Revise 6-4.3.4 as follows: In the third line, delete the word "sulfide" *and remove the parentheses around the word* "insulating."

7. Revise 7-2.8.1.2 as follows: After first sentence add: "See Appendix A, ANSI C107.1–1974."

8. Revise 9-7 as follows: Revise the title to read: "Motor Overload Relays — Thermal Types."

9. Revise 9-7.1 as follows: Relocate the last two sentences to follow the first sentence in this section.

At the beginning of the present second sentence add the word "Such."

In the present fourth sentence change the word "solder" *to* "alloy."

10. Add a new 9-7.2 to read as follows:

9-7.2 Other Types. Refer to manufacturer's literature for maintenance of other types of overload devices.

11. Renumber present 9-7.2 and 9-7.3 to 9-7.3 and 9-7.4.

12. Present Chapter 10 (Molded Case Circuit Breaker Power Panels) to be renumbered Chapter 11 with appropriate sections renumbered accordingly. There are no other changes in this Chapter.

13. Present Chapter 11 (Fuses) to be renumbered Chapter 13 with appropriate sections renumbered accordingly.

14. Renumber present 11-2.3.4 to 13-2.3.4 and revise the last sentence to read: "If the seals are damaged or show evidence of leakage, the fuses should be replaced."

15. Add a new Chapter 10 to read as follows:

Chapter 10 Electronic Equipment

10-1 General. The purpose of this section is to describe the maintenance of electronic equipment in general terms. Specific maintenance procedures normally are available from the equipment manufacturer or contained in the instruction book supplied with the apparatus. In some cases these procedures require the services of trained specialists.

10-2 Reasons for Maintenance.

10-2.1 Maintenance procedures are designed to:

(a) Protect the equipment from adverse effects of heat, dust, moisture, and other contaminants.

(b) Maintain rop reliability and minimize costly downtime.

(c) Prolong the useful life of the equipment.

(d) Recognize incipient problems and take corrective action.

10-2.2 The importance of maintenance cannot be overemphasized. Equipment must be kept operating efficiently to contribute to the success of the process or operation in which the equipment is employed. Apparatus that is improperly maintained will soon become unreliable.

10-2.3 Persons charged with maintenance responsibility should have a keen appreciation as to why the work is required and the importance of even routine aspects of maintenance to the overall performance of the equipment.

10-3 Special Safety Precautions.

10-3.1 Special safety precautions should be observed before and during the preventive maintenance operation. Extreme care should be taken to assure that all power is removed from the apparatus before servicing. To prevent accidental shock from the stored energy in capacitors, discharge them to ground or short circuit the leads before touching with bare hands. High voltage capacitors should be discharged by short circuiting the leads for at least one full minute. Parts such as tubes, resistors, heat sinks, etc., remain extremely hot for some time after power has been removed. Some component temperatures are very high and can cause very painful burns if contacted by bare skin.

10-3.2 An accidental shock or a bad burn may cause an involuntary movement by a person's arm or body which can damage the equipment and injure personnel.

10-3.3 Occasionally, some equipment employing high voltages require troubleshooting while the circuits are energized. Ensure that the insulation on test equipment leads are fully rated for the operating voltage under test and in good shape mechanically. Special care should be observed when using or servicing equipment which employs the chassis as one side of the circuit. Such equipment may be hazardous in the presence of grounded or some ungrounded three-phase circuits.

10-4 Preventive Maintenance Operations. Actual work performed during maintenance consists of the following operations:

(a) Cleaning.

(b) Inspection.

(c) Adjustments.

(d) Lubrication.

10-4.1 Cleaning. Cleaning the apparatus, both inside and out, is essential for good operation. Dust, etc., will increase chances of current leakage or flashover with resultant malfunction or damage to critical parts. Any accumulation of dust should be removed with a vacuum cleaner, if possible, or manually cleaned during maintenance shut-down periods. Enclosure filters should be cleaned at regular intervals and replaced when damaged or clogged.

10-4.2 Inspection. Inspection is most important in the maintenance program. Slight abnormalities may not immediately interfere with the equipment performances, but deviations from normal should be discovered early. Time and effort can be saved if defects are corrected before they lead to major breakdowns. Inspections consist of carefully observing all parts of equipment, noticing their color, placement, state of cleanliness, etc. Inspect for conditions such as:

(a) Overheating; indicated by discoloration or other visual characteristics.

(b) Placement; by observing leads and cable clearances, rub points, etc.

(c) Cleanliness; examine recesses for accumulation of dust, especially between connecting terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign material.

(d) Tightness; test soldered or screw terminal connections and mountings by slightly pulling on the wire or feeling the lug or terminal screw.

10-4.3 Adjustments. Adjustments should be made only when performance indicates that it is required in order to maintain normal operating conditions. Specific adjustments vary with each type of equipment and will be contained in the instruction booklets supplied with the apparatus. Equipment calibrations should be scheduled on a routine basis with the frequency depending on individual operating conditions peculiar to the process or equipment.

10-4.4 Lubrication. Lubrication refers to application of grease or oil to bearings of motors, rotating shafts, gears, etc. This can also include light lubrication to door hinges or other sliding surfaces on the equipment. Some special parts are identified as being pre-lubricated for life and should require no further lubrication.

10-4.5 Careful handling of electronic equipment should become a regular habit. Space for working on components partially covered by other components should not be made by pushing or moving other components out of the way. Avoid unnecessary strains on wires, cables, and connections, and maintain equipment in a neat, orderly, workmanlike manner.

16. Add a new Chapter 12 to read as follows:

Chapter 12 Ground-Fault Protection

12-1 General.

12-1.1 Ground-fault protective devices intended to protect personnel or systems from ground faults are of two distinct types and IT IS EXTREMELY IMPORTANT TO UNDERSTAND THE DIFFERENCE BETWEEN THEM.

(a) GFCI — Ground-Fault Circuit-Interrupter. A GFCI is designed to protect a person from electrocution when contact between a live part of the protected circuit and ground causes current to flow through a person's body.

A GFCI will disconnect the circuit when a current equal to or higher than the calibration point (4 to 6 mA) flows from the protected circuit to ground. It will not eliminate the shock sensation since normal perception level is approximately 5 mA. It will not protect from electrocution on line-to-line contact since the nature of line-to-line loads cannot be distinguished.

(b) GFP — Ground-Fault Protector. A GFP is designed to limit damage to electrical equipment in the event of a fault (either solid or arcing) between a live part of the protected circuit and ground. A GFP will cause the circuit to be disconnected when a

current equal to or higher than its setting flows to ground. GFP's are available with settings typically ranging from 5 to 1200 amperes. It will not protect personnel from electrocution.

12-2 Ground-Fault Circuit-Interrupters (GFCI).

12-2.1 GFCI's are equipped with an integral test means for checking the tripping operation.

12-2.2 Maintenance.

12-2.2.1 The devices are sealed at the factory, and maintenance should be limited to that recommended as follows or by the manufacturer.

12-2.2.2 Separate test apparatus is available which may be used for acceptance testing and troubleshooting of GFCI's.

12-2.2.3 In addition to the maintenance specified for the individual types of GFCI, tripping tests should be performed with the test button on the unit in accordance with the frequency recommended by the manufacturer. Results and date of tests should be recorded on the test record label or card supplied with each permanently installed GFCI unit.

12-2.3 The four types of GFCI's are:

(a) Circuit breaker type.

(b) Receptacle type.

(c) Portable type.

(d) Permanently mounted type.

12-2.4 A circuit breaker type GFCI is designed in the form of a small circuit breaker and is completely self-contained within the unit housing. The circuit breaker type GFCI provides overload and short-circuit protection for the circuit conductors in addition to ground-fault protection for personnel. It is intended to be mounted in a panelboard or other enclosure.

12-2.4.1 Maintenance required is the same as specified in Chapter 10 for Molded Case Circuit Breakers.

12-2.5 A receptacle type GFCI is designed in the form of a standard receptable and is completely self-contained within the unit housing, and does not provide overload or short-circuit protection. It is intended for permanent installation in conventional device outlet boxes or other suitable enclosures.

12-2.5.1 Maintenance required will be the same as specified in Section 16-3 for standard receptacle outlets.

12-2.6 A portable type GFCI is a unit intended to be easily transported and plugged into a receptacle outlet. Cords, tools, or other devices to be provided with ground-fault protection for personnel are then plugged into receptacles mounted in the unit.

12-2.6.1 Maintenance required will be that specified in Section 16-3 for receptacles and in Section 17-4 for the connecting cords.

12-2.7 A permanently mounted type GFCI is a self-contained, enclosed unit designed to be wall or pole mounted and permanently wired into the circuit to be protected.

12-2.7.1 Maintenance beyond tightness of connections and cleanliness should not be attempted. Any repairs needed should be referred to the manufacturer.

12-3 Ground-Fault Protectors (GFP).

12-3.1 A GFP system is designed to be installed in a grounded distribution system. A GFP system consists of three main components: 1) sensors, 2) relay or control unit, and 3) a tripping means for the disconnect device controlling the protected circuit. Acceptance testing of the complete system is recommended before utilization of the equipment.

12-3.2 Detection of ground-fault current is done by either of two basic methods. With one method, ground current flow is detected by sensing current in the grounding conductor. With the other method, all conductor currents are monitored by either a single large sensor, or several smaller ones.

12-3.3 Sensors are generally a type of current transformer and are installed on the circuit conductors. The relay or control unit may be remotely mounted from the sensors or may be integral with the sensor assembly.

12-3.4 Circuit breakers with electronic trip units may have a GFP system integral with the circuit breaker. Any maintenance work performed on the electronic circuitry should adhere to manufacturer's instructions. Maintenance on the mechanical operating mechanism components should be done as indicated in Chapter 11.

12-3.5 Maintenance.

12-3.5.1 Maintenance requirements for the sensors are as specified in Chapter 6, Subsection 6-8.5.2 for Indoor Type Instrument Transformers. Make careful inspection for tight terminal connections and cleanliness. Any repairs needed should be performed by the manufacturer.

12-3.5.2 If interconnections between components are disconnected, they must be marked and replaced to maintain the proper phasing and circuitry.

12-3.5.3 If the system is equipped with a test panel, a formal program of periodic testing should be established. When the system is not equipped with a test panel, refer to manufacturer for test instructions.

17. Present Chapter 12 (Rotating Equipment) to be renumbered Chapter 14 with appropriate sections to be renumbered accordingly. There are no other changes in this Chapter.

18. Present Chapter 13 (Lighting) to be renumbered Chapter 15 with appropriate sections to be renumbered accordingly. There are no other changes in this Chapter.

19. Present Chapter 14 (Portable Electric Tools and Equipment) to be renumbered Chapter 17 with appropriate sections to be renumbered accordingly. There are no other changes in this Chapter.

20. Add a new Chapter 16 to read as follows:

Chapter 16 Wiring Devices

16-1 Attachment Plugs, Cord Connectors and Receptacles.

16-1.1 General. This section covers the maintenance of attachment plugs, cord connectors and receptacles rated not more than 200 amperes nor more than 600 volts.

16-1.2 The connection of equipment to supplies of different electrical ratings of current, voltage, phase or frequency can be hazardous or can cause damage to equipment. Therefore, attachment plugs, cord connectors and equipment are provided with different ratings and configurations to prevent hazardous interconnection.

NOTE: See Appendices G-1 and G-2 for ANSI C73 Configuration Chart.

16-1.3 The use of these devices for the connection of equipment provides for rapid removal and replacement and facilitates relocation.

16-1.4 Up to 60 amperes, all devices are tested for the capability of being connected or disconnected under full load. Devices rated above 60 amperes are marked as to whether they are listed for this mode of operation.

16-1.5 Use of these devices to disconnect some equipment under some load conditions such as welders and running or stalled motors may be hazardous. Other load interrupting means intended for this purpose should be used.

16-2 Attachment Plugs and Connector Bodies.

16-2.1 Assure that cord clamps and other strain-relief fittings are tight and that the outer cord jacket is completely within the clamping area.

16-2.2 Wire terminations on attachment plugs should be covered by insulating discs or the device should be replaced with a dead-front type. Abnormal heating on the plug surface may be caused by loose terminations, overloading, high ambients or equipment malfunction. The assembly of individual conductors to terminals should be checked periodically. Individual conductor strands must be properly confined and terminations made tight. Conductor strands should not be solder-dipped since this may cause overheating.

16-2.3 If the attachment plug or connector body is cracked or distorted or pieces are missing or damaged, or if the blades, prongs or contacts are bent or missing, the device should be replaced. If this is a recurring problem the device should be replaced with a type suitable for the environment in which it is used. For special applications and environments such as wet locations, highly corrosive environments, and high temperature locations, special service devices specifically intended for the purpose should be used.

16-2.4 Attachment plugs should fit firmly when inserted into the mating connector or receptacle. If accidental disengagement of the plug is a recurring problem, the connector or receptacle should be tested to assure that adequate contact pressure is present. When continuity of service is essential, consideration may be given to the installation of a locking-type device.

16-2.5 Assure proper polarity of all connections.

16-2.6 The green equipment grounding conductor of the cord must be attached to the grounding terminal of the device.

16-3 Receptacles.

16-3.1 If the receptacle is badly worn, cracked, or broken, or if contacts are exposed, the receptacle should be replaced.

16-3.2 Receptacle contacts must hold and retain inserted plugs firmly. If accidental disengagement of the plug from the

receptacle is a recurring problem the receptacle should be replaced. When continuity of service is essential, consideration should be given to the installation of a locking-type device.

16-3.3 Check to assure for proper wire connections on receptacles and proper polarity of power connections including the integrity of the equipment ground.

16-3.4 In addition to testing for polarity and equipment grounding continuity, ground loop impedance testing may be used to detect some forms of poor grounds. Refer to Section 18-13.

16-3.5 When replacing 15- and 20-ampere nongrounding-type receptacles, grounding-type receptacles should be installed and, where used, must be grounded.

16-3.6 If there is abnormal heating on the receptacle face, check for loose terminations and correct or replace. If there is arc-tracking or evidence of burning of the device or other damage, it should be replaced.

16-4 Adapters.

16-4.1 Adapters between locking and nonlocking configurations provide flexibility in obtaining power for maintenance functions. However, adapters should not be used to by-pass the equipment ground, nor should adapters with pigtails be used.

16-5 General-Use Snap Switches.

16-5.1 AC-DC (T-Rated) switches should not be used to control inductive loads such as fluorescent lighting or motors exceeding 50 percent of the switch rating. AC only switches may control up to 100 percent of their rating for inductive loads or 80 percent of their rating for motor loads.

16-5.2 If the switch is broken or the mechanism does not function in a normal manner, the switch should be replaced. Where repeated abuse is incurred, consideration should be given to relocating the switch or replacement with a switch having a guarded operating means or a switch with a low profile.

16-5.3 The switch must be firmly fastened to the box to assure electrical and mechanical integrity.

16-5.4 If there is evidence of abnormal heating, the switch should be checked for loose terminals or switch malfunction and corrected or replaced.

16-6 Cover Plates.

16-6.1 All switches and receptacles should be installed with wall plates or covers suitable for the environment and location.

16-6.2 Cracked, bent, or broken wall plates or spring doors or covers should be replaced.

16-6.3 Boxes. Boxes used for the containment of receptacles and switches should be rigidly secured in place. Locknuts and conduit fittings should be made up tight and proper box-fill of conductors should be observed. Closures should be placed in unused knock-out holes. Where boxes, particularly the surface-mounted type, sustain repeated abuse, consideration should be given to flush-mounting and/or additional guarding means.

21. Present Chapter 15 (Testing and Test Methods) to be renumbered Chapter 18 with appropriate sections renumbered accordingly.

22. Renumber present 15-10.2.1, 15-10.2.2, and 15-10.2.5 and revise as follows:

18-10.2.1 In the next to the last line between the words "team" *and* "be" *add the parenthetical clause* "(either in-house or outside contractor.)"

18-10.2.2 To the beginning of the first sentence add the words "Where needed."

18-10.2.5 Substitute the words "Molded Case" *for* "Low Voltage Power."

23. Add a new Section 18-13 to read as follows:

18-13 Ground Loop Impedance Testing.

18-13.1 Ground loop impedance testing is used to determine the total alternating current resistance of the circuit that would be involved under fault conditions. This circuit would include the phase conductor, the equipment grounding conductor, the portion of the neutral or grounded circuit conductor which is between the bonding jumper and the secondary windings of the supply, and finally, the secondary windings themselves.

18-13.2 The test is conducted by using a ground loop impedance tester. The tester places a limited fault current (about 20 amperes) on the circuit under test for a limited time (about 20 milliseconds). By measuring the voltage drop across a reference resistor, the tester indicates the ohmic value of the fault loop.

18-13.3 Ground loop impedance tests should be used to identify circuits with high resistance. The high resistance may denote poor connections or excessive conductor lengths. Low ohmic values, while a good indication, do not assure that all elements of the circuit have sufficient capacity to handle large ground faults. Good workmanship and careful visual inspection are essential in establishing the system's integrity.

24. Renumber the remainder of Chapter 18 accordingly.

25. Add a new Chapter 19 to read as follows:

Chapter 19 Maintenance of Electrical Equipment Subject to Long Intervals Between Shutdowns

19-1 General.

19-1.1 Due to the more extensive and costly damage possible from electrical failures in continuous process operations, plus the longer intervals between shutdowns, more thorough and comprehensive maintenance procedures are recommended. The need for and frequency of inspection and maintenance is determined by the effect on safety, plant operation and severity of service.

The primary effects of electrical failure or malfunction are those directly associated with the failure, and usually involve the damage to electrical equipment. The secondary effects are those associated with the process and/or product. Damages resulting from secondary effects can be much more extensive and in some cases catastrophic.

19-1.2 In addition to more intensive maintenance procedures, this chapter will cover system design considerations in so far as they relate to safety and maintain ability as well as first and future costs.

19-2 Electrical Distribution.

19-2.1 General Aspects of Maintaining High, Medium, and Low Voltage Systems.

19-2.1.1 Unless an electrical distribution system is adequately engineered, designed, and constructed, it will not provide reliable service no matter how good the maintenance program. Therefore, the following requirements are much more essential for electrical distribution systems which supply production equipment that must operate for long periods between shutdowns:

(a) Careful planning in the engineering and design stages to permit maintenance work without load interruptions. Alternate electrical equipment and circuits should be provided to permit routine or emergency maintenance on one while the other supplies the load that cannot be shut down. For instance, automatic or manual transfer equipment will permit the load to be switched, with minimal interruption, from a source or circuit that fails to one that is operating.

(b) High quality equipment that has sufficient capacity and features that permit reasonable inspection of the energized parts while in operation without hazard to an inspector using proper precautions. Viewing windows or expanded metal guards inside hinged doors provide a safe means for inspecting energized components inside enclosures. Complete barriers between adjacent switch and breaker sections, etc., will permit personnel to work safely inside a de-energized compartment while adjacent ones are energized.

Close inspection of the equipment before shipment is the best way to certify compliance with specifications.

(c) Strict adherence to construction specifications complete with detailed drawings and installation procedures.

(d) Close scrutiny during all phases of construction is eseential to ensure adequate quality workmanship and that cables, insulating materials, and other components are not damaged by poor practices.

(e) Acceptance testing (in accordance with applicable recognized standards) including functional testing and inspection. These are valuable to detect equipment that is defective, badly damaged, or installed in an inferior manner. In addition, reinspection and retesting within one or two years after energization may reveal conditions which can lead to in-service failures.

19-2.1.2 After these prerequisites are satisfied, an adequate EPM program will help to keep the system in good condition and provide the necessary reliability over a long period.

19-2.1.3 Maintenance, inspection, and test methods for equipment that must operate for long periods are essentially the same as for equipment that may be shut down frequently. However, the required work must be performed with more care and diligence to obtain the desired reliability for service to loads that must operate continuously for months or years.

19-2.1.4 The following is necessary to effect an adequate EPM program for reliable long-term operation of an electrical power system:

(a) Good knowledge of the entire power system by all associated personnel. Posted or readily available diagrams, procedures, and precautions are highly beneficial aids in keeping personnel knowledge up to date.

(b) General understanding of the loads served and their electrical quality and continuity of service requirements.

(c) Length of time between scheduled maintenance shutdowns for utilization equipment, process changes, etc., that will influence the length of intervals between electrical power system maintenance shutdowns.

(d) A complete list of all the electrical system equipment associated with a given process or manufacturing system to assure that all of it is maintained during one shutdown instead of doing it piece-meal which would require additional shutdowns.

(e) The amount of time during the utilization equipment shutdown when the electrical power system can be de-energized for EPM.

(f) Knowledge of electrical power system components, including operating and maintenance data. This information is often included in the manufacturers' maintenance instructions.

(g) Knowledge of ambient conditions, such as heat, moisture, and vibration, that may affect the equipment.

(h) Ability to recognize abnormal conditions and early evidence of potential problems, such as overheating and surface tracking on insulating materials, that can cause failure if not corrected in sufficient time.

(i) Standardized maintenance procedures shown in other portions of the text modified by the above information and knowledge gained through experience.

(j) Knowledge of services available from local, area, and national electrical maintenance contractors that have specialized test equipment and highly qualified personnel who routinely perform this work. Some of the items that fall into this category are: relay calibration and testing; circuit breaker overcurrent trip device calibration and testing; high potential testing; power factor testing; insulating liquid testing and reconditioning; switchgear maintenance and testing; and maintenance and testing of solid state devices.

Unless the amount of specialized work is sufficient to keep plant electrical maintenance personnel adept in the performance of such work, the use of specialized electrical maintenance contractors should be considered. However, plant maintenance supervision must have sufficient electrical knowledge to decide with the contractor on the required work to be done and to closely follow his performance to assure full compliance. Merely telling a contractor to maintain and/or test the equipment usually creates a false sense of security that can be shattered by a serious failure caused by inadequate or incorrect maintenance procedures. The result is often the same when plant supervision does not sufficiently instruct plant maintenance personnel.

19-2.1.5 When a piece of equipment or component fails, merely making repairs or replacement is not sufficient. A complete analysis should be made to determine the cause and formulate corrective action to prevent recurrence in the same and similar equipment.

Following is a list of maintenance, inspection, and testing guide tables for various types of equipment which are located in the appendix. The material contained therein is of a general nature and may have to be revised to conform more closely with the equipment being maintained to assure the coverage necessary for the required reliability. Experience has indicated that the frequencies of maintenance, etc., shown in the tables is sufficient for most installations. They might have to be tailored to suit installations where the ambient conditions are more or less severe.

(a) High- and Medium-Voltage Equipment (Over 1,000V).

1. Cables, Terminations, and Connections.
2. Liquid-filled Transformers.
3. Dry-type Transformers.
4. Metal-clad Switchgear.
5. Circuit Breakers.
6. Metal-enclosed Switches.
7. Bus Ducts.
8. Protective Relays.
9. Automatic Transfer Control Equipment.
10. Fuses.
11. Lightning Arresters.

(b) High, Medium-, and Low-Voltage Equipment.

1. Overhead Lines.

(c) Low-Voltage Equipment (Below 1,000V).

1. Cables and Connections.
2. Dry-type Transformers.
3. Switchgear.

4. Drawout-type Circuit Breakers.
5. Buses and Bus Ducts.
6. Panelboards.
7. Protective Relays.
8. Automatic Transfer Control Equipment.
9. Circuit Breaker Overcurrent Trip Devices.
10. Fuses.
11. Lightning Arresters.

19-3 Utilization.

19-3.1 General.

19-3.1.1 The utilization of electrical energy in industry is the conversion of electrical energy into useful work such as mechanical operations, lighting, and heating. Of primary concern is the maintenance of the many kinds of utilization equipment used with processes that operate for long intervals between shutdowns. Utilization equipment as covered here is considered to operate at 480 volts and less.

19-3.1.2 Chapters 4 and 5 make reference to the need for planning and developing an EPM program and describe some of the fundamentals. Utilization equipment that serves equipment that operates for long intervals between shutdown should receive special consideration. The serviceability and safety of the equipment should be thoroughly studied. During the initial design stages, thought needs to be given towards EPM with ease of maintenance and accessibility being of extreme importance in the design considerations, with emphasis on access for adequate visual inspection of all busbars and joints.

19-3.1.3 Maintenance personnel who are going to service the equipment should be consulted during the design phases.

19-3.2 Records and Inspection Tours.

19-3.2.1 Keeping records on utilization equipment that operates over long intervals is more important than short-interval equipment. Wiring changes, parts replacement, and other modifications should all be accurately recorded.

19-3.2.2 Schedules should be laid out for periodic inspection tours of utilization equipment. Records of findings on these inspection tours will help to indicate trends. Another important reason for good record keeping is that personnel often change and it is necessary for those presently involved to know what has been done prior to involvement.

19-3.2.3 Power and lighting panels directories must be kept up to date and be accurate.

19-3.3 Power Distribution Panels.

19-3.3.1 Power distribution panels can either be fuse or circuit breaker type panels. Where critical circuits are involved, they should be appropriately identified by tags, labels, or color coding.

19-3.3.2 Seldom are power panels de-energized and then only for circuit changes; it is at this time EPM can be scheduled. Although procedures can be developed for working on them live, it is not recommended because of the safety hazards involved and there is always the possibility of an error or accidental tripping of a main breaker causing an unscheduled shutdown. During operating periods the panels can only be checked for hot spots or excessive heat and this should be done at a reasonable interval in accordance with the importance of the circuit. A record should be made of areas that have given trouble; do not rely on memory.

19-3.3.3 During a shutdown and while the panel is dead, all bolted connections should be checked for tightness, and visually inspected for discoloration. Should there be discoloration, further investigation should be made and possibly the parts affected be replaced. For further information, refer to Chapters 11 and 13.

19-3.4 Lighting Panels.

19-3.4.1 Lighting panels generally have the same problems as power panels. However, experience indicates a higher probability of circuit overloading and thus protective device overheating. Since such panels applied in long-term maintenance areas usually feed important circuits, overheating problems should be corrected immediately.

19-3.5 Plug-in Type Bus Duct.

19-3.5.1 Since plug-in bus duct is seldom used in long-term areas, maintenance of this equipment will not be covered here. Refer to Chapters 9, 11 and 13 for related information.

19-3.6 Wiring to Utilization Equipment.

19-3.6.1 Maintenance procedures outlined in Chapter 8 are recommended. The visual inspection interval should be based on the importance of the circuits and previous experience. In addition, more extensive insulation testing may be warranted during shutdown periods to ensure higher reliability.

19-3.7 Rotating Equipment.

19-3.7.1 Proper maintenance of electric motors and rotating equipment is essential to prevent unscheduled downtime. Their most trouble-prone parts are bearings. The quantity of lubricant, the frequency of lubrication, the method of application, and the type of lubricant are of prime concern. Although lubrication of rotating equipment is discussed in Chapter 14, it is important enough with equipment that operates for long periods between shutdowns, and especially motors, that further mention is made here. Suggestions for both oil and grease lubrication systems are listed below.

19-3.7.2 Grease Lubrication Systems. Grease is the most common lubricant used for electric motor bearings. It provides a good seal against the entrance of dirt into the bearing, has good stability, is easy to apply, and is easy to contain without elaborate seals. A high quality ball and roller bearing grease is one that has National Lubrication Grease Institute number 2 or 3 lithium-base with rust and oxidation inhibitors. For extended service intervals, an extremely stable grease is required. Grease should be selected on the basis of the expected temperature range of service. The motor manufacturer or most oil companies can provide advice on exactly which grease to use. The major limiting factor for grease is the speed of the bearing.

19-3.7.3 Quantity. The correct quantity of lubricant in a rolling contact bearing is vital to its proper operation. Insufficient lubricant will result in failure. Over-lubrication will develop excessive heat which also results in bearing failure. The optimum quantity of grease in a bearing is from ⅓ to ½ of its open area filled with grease. Sealed bearings in "Lubricated for Life" motors are packed with this quantity at the factory. They cannot be relubricated with a grease gun through a fitting. Open or shielded bearings on integral horsepower motors require their lubricant reservoir refilled periodically to ⅓ to ½ full of grease or in accordance with the motor manufacturer's recommendation. New motors are supplied with the proper amount of lubricant in their reservoirs. They do not require addition of lubricant prior to startup.

The quantities in Table 19-3.7.3 may be used as a guide for refilling the grease reservoir. Good judgment must be exercised in all cases. Under most conditions, these quantities represent the amount required to refill the bearing housing ⅓ to ½ full.

Table 19-3.7.3

Guidelines for Grease Quantities vs Motor Frame Size

Motor Frame Size		Quantity to Fill Housing ⅓ - ½ Full	
		Ounces	Maximum Number of Shots*
182 –215	143T–184T	.4	12
254U–256U	213T–215T	.5	15
284U–286U	254T–256TS	.6	18
324U–326US	284T–286TS	.8	24
364U–365US	324T–326TS	1.0	30
404U–445US	364T–405TS	1.3	39
	444T–449TS	1.6	48

*Standard lever-type grease gun.

19-3.7.4 Frequency of Application. The frequency of grease lubrication is another vital factor in the proper functioning of an electric motor. The normal frequency range is from one year to five years depending on the environment and shaft speed.

Table 19-3.7.4 can be used as a guide when no formal lubrication schedule has been established.

Table 19-3.7.4

Motor Lubrication Schedule

Shaft Speed (RPM)	Environment			
	Operating Temperature	Bearing Load	Atmosphere	Frequency
1800 & Below	0°F to 180°F	Moderate Shock and/or Vibration	Indoors — Typical Industrial	5 Years
		Heavy Shock and/or Vibration	Outdoors, Water Chem., Heavy Dirt	1 Year
3600	0°F to 180°F	Moderate Shock and/or Vibration	Indoors — Typical Industrial	2 Years
		Heavy Shock and/or Vibration	Outdoors, Water Chem., Heavy Dirt	1 Year
Above 180°F, contact any major oil company				

19-3.7.5 Method of Application. The standard lever-type grease gun should be used to apply grease to the motor bearing through a standard grease fitting. The fitting should be mounted as close to the housing as possible. An extension pipe or tube should be used only when the fitting is inaccessible. Lubricating grease is a mixture of oil and metal soap which tend to separate with time. Thus, hard soap deposits can accumulate, causing plugged lines. The housing should have a relief fitting located 180° from the grease fitting. A relief-type grease fitting is recommended over a pipe plug for ease of maintenance.

19-3.7.6 Oil Lubrication Systems. Oil lubrication is necessary when a motor is equipped with sleeve bearings. It is sometimes used for roller contact bearings under certain conditions.

Oils for lubricating electrical motors should be high quality circulating oils with rust and oxidation inhibitors.

The oil viscosity required for optimum operation of motor bearings is determined by the motor speed and the operating temperature.

The three oil viscosities most commonly required for electric motor bearings are International Standards Organization (ISO) Viscosity Grade (VG) 32, 68, and 150. These ISO viscosity grades are measured in centistokes (CST) at 40°C (104°F). See Table 19-3.7.6.

The oil level should be such that a 60° segment of the oil ring on the inside diameter is immersed while the motor shaft is at rest. A sight glass, constant level oiler, or some other unit is provided to mark and observe the oil level. Levels should be marked for the at-rest condition and the operating condition.

19-3.7.7 Methods and Quantity.

(a) Wick Oiling. Fractional horsepower motors which can be relubricated generally use felt, waste, or yarn packing to feed sleeve bearings. The packing should be saturated at each lubrication interval.

(b) Ring Oiling. Integral horsepower motors may have ring lubricated sleeve bearings. The rings are located in a slot in the upper half of the bearing and ride loosely on the shaft. There are normally no more than two rings for each bearing. Free turning of the rings should be checked on starting a new motor, at each inspection period, and after maintenance work. When the motor is running, the oil level should be above the lowest point of the inner radius of the ring as it hangs on the shaft. A visual method of determining this level is usually provided.

Table 19-3.7.6

Oil Viscosity vs Motor Speed (16°C to 60°C)

Motor Speed (RPM)	Oil Viscosity (ISO VG CST)*		
	Ball & Roller Brg.	Sleeve Brg.	
	HP — All	HP-Fractional	HP-Integral
3600	32	32	32
1800	68	68	32
1200	68	68	68
900	68	68	68
720	150	150	68
600	150	150	68

Approximate Equivalents

150 VG Centistoke Units	Saybolt Universal Seconds Units
32	150
68	315
150	700

*The ISO Viscosity Grade number represents the nominal viscosity in centistokes (± 10%) measured at 40°C (104°F). See ASTM D-2422-76, *Viscosity Systems for Industrial Fluid Lubricants.*

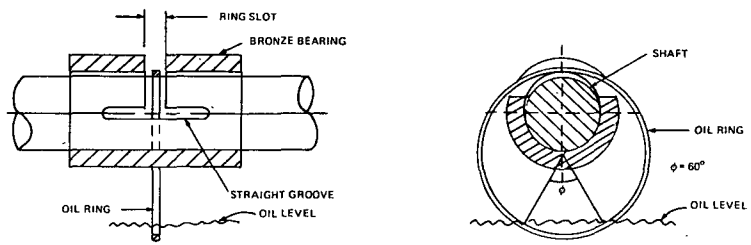

Fig. 19-3.7.7(b)

(c) Bath Oiling. Large, vertical motors frequently have a surrounding oil bath for lubrication of either rolling element bearings or plain thrust bearings. Horizontal units equipped with ball and roller bearings may also have an oil bath. The proper oil level is determined by the manufacturer and is dependent upon the bearing system. A sight glass, constant level oiler, or some

other unit is provided to mark and observe the oil level. This level may change depending on whether the motor is operating or at rest. It should be marked for both situations.

19-3.7.8 Frequency. In oil lubricating systems it is required that the oil level be maintained. This is observed by means of a sight glass, constant level oiler, etc., and oil is added as required. Normally, these systems should be drained and refilled on an annual basis. Wick oil systems require addition of oil quarterly and the wick should be saturated.

19-3.7.9 Motor Inspections. Visual inspections should be performed on a periodic basis. These inspections are necessary to detect mechanical or lubrication deficiencies before they become serious. The inspection should include a check for increase in temperature, excessive bearing noise, excessive vibration, and lubricant leakage. If any of these conditions exist, the cause should be located and corrected.

19-3.8 Vibration Tests and Analysis.

19-3.8.1 Sleeve bearings fail due to a loss of oil film resulting from wear, leakage, etc. These failures are sudden; and without constant vibration monitoring equipment, they cannot be predicted.

19-3.8.2 Life of a ball or roller bearing is defined as the number of revolutions or hours of operation at constant speed, which the bearing is capable of running before fatigue develops. If a bearing is properly lubricated, mounted, and handled, all causes of failure are eliminated except one, fatigue of the material. These failures initiate with removal of metal from the races or rolling elements. Vibration analyzing equipment cannot be used to predict these failures. The vibration from these failures can be audibly detected by personnel in the area by the time they can be detected by vibration equipment. Such equipment is useful in isolating the source of vibration which may appear to be the result of other malfunction within a motor. It is also useful for ensuring proper installation of critical production equipment.

19-3.8.3 Vibration analyzers are very handy tools to detect trouble and prevent downtime. A formal vibration analysis program can reduce costly machine failures. The program can range from the use of simple hand held analyzers to sophisticated multi-channel recorders with permanently mounted sensors to provide data for comparison of vibration comparisons. Such a program

makes it possible to keep track of the condition of rotating equipment, particularly high speed types. Trend charts will assist in establishing maintenance needs. The degree of sophistication depends upon the application, but even a hand held vibrograph is a useful tool in EPM.

19-3.9 Dirt.

19-3.9.1 Where rotating equipment is exposed to dirt, regular inspection is needed to detect when cleaning is needed. A major cause of burned out motors is clogged air passages. On motors in dirty atmospheres, filters (where used) frequently become clogged, therefore, filter cleaning or changing should be scheduled. The external surface of motors should be kept cleaned because a pile-up of dirt restricts heat dissipation and this is particularly important with "T" frame motors. Refer to Chapter 14 for cleaning methods. In dirty locations and critical applications, more extensive insulation testing may be warranted as described in Chapter 18. Excessive leakage current may well indicate that a motor failure is imminent.

19-3.10 Control for Rotating Equipment.

19-3.10.1 This involves the motor starters, contactors and other devices that are directly involved with the control of equipment operating over long periods between shutdowns. The maintenance recommendations of Chapter 9 are pertinent to equipment operating for long periods between shutdowns.

19-3.10.2 While the equipment is in operation, EPM procedures must be modified. Where control panels can be opened while energized, any terminals with a voltage greater than 150 volts to ground should be covered with a transparent protective covering to permit visual inspection. Essentially EPM will be limited to visual inspection. Be sure that adequate ventilation is maintained within enclosures. Gaskets should be kept in good repair where used and the atmosphere is dirty. Contact wear should be observed where possible.

19-3.11 Redundancy.

19-3.11.1 Although it is expensive, redundant circuits and equipment are often necessary to ensure continuity of operation. During initial design stages and even at later times, consideration should be given as to what is needed to prevent unscheduled shutdowns and high maintenance costs. Frequently, redundancy on critical circuits provides the solution.

19-3.12 Heating Equipment.

19-3.12.1 In general, this equipment cannot be maintained while it is in operation. Perhaps rotating parts are not involved but certainly there is heat and the potential of serious burns that exist here.

19-3.12.2 In most process heating systems continuous cycling or on-off operation is being carried out. This cycling will cause a certain amount of temperature change. As a result, particular attention must be paid to all connections and joints. The use of "Belleville" washers has been successful in maintaining tight connections. During the time the equipment is in operation, visually inspect all joints and terminations and look for signs of heating or arcing that would indicate loose joints. The cycling frequently will cause some movement of the wiring; therefore, check the insulation on the wiring where it passes through nipples, access holes and other openings.

19-3.13 Electrostatics — Static Grounding.

19-3.13.1 The purpose of static grounding is to remove the accumulation of static electricity on equipment, on materials being handled or processed, or on operating personnel that can build up during machine operation. On equipment that is in continuous operation, regular inspection and repair procedures should be developed and maintained in order to retain the integrity of the grounding continuity.

Since the static charge can build up to several thousand volts, consideration should be given during the initial construction of equipment to reduce the buildup. Equipment is made up of conductors (metal-machine frame) and insulators (conveyor belts, plastic parts, etc.). Usually some part of a machine is grounded either electrically or by virtue of construction. Machine parts may be grounded directly or by bonding them to other machine parts which are grounded. Clean, unpainted metal nuts and bolts holding together clean, unpainted metal parts provide adequate continuity. Bonding and grounding may be accomplished by permanently attached jumper wires. When such wires are attached by lugs or placed under bolt heads or nuts, all parts must be clean and unpainted before installation. Any painting of parts used for static grounding should be done only after such parts are properly installed and the adequacy of the ground is certified. Slowly rotating parts are normally adequately bonded or grounded through the bearings. However, parts rotating at high RPM's, such as baskets or centrifuges, should be bonded or grounded by wipers, carbon brushes or other devices. Portable equipment can be temporarily grounded by clamping a static ground wire to the equipment.

19-3.13.2 Adequate Static Grounding. It might be necessary to obtain the recommendations of people who are experts in a particular static grounding problem. However, some guidelines that will provide adequate static grounding are listed below.

(a) Static charging currents rarely exceed one microampere and often are smaller. Thus leakage currents of the order of microamperes will provide protection against the accumulation of static electricity to dangerously high potentials.

(b) A leakage resistance between a conductor and ground as high as 10,000 megohms will provide adequate static grounding in many cases. However, when charges are generated rapidly, a leakage resistance as low as one megohm may be necessary.

(c) The leakage resistance necessary for adequate static grounding will vary among different operations and must be established by qualified authority. In the absence of any specifications, the leakage resistance from any conductor to ground should not exceed one megohm.

(d) There is no electrical restriction in conductor size for static ground wires and jumpers, but larger size conductors may be required to limit physical damage. However, where a conductor used for static grounding is also the equipment grounding conductor for a power circuit, the conductor must be sized in accordance with Table 250-95 of NFPA 70–1975.

(e) A static ground wire need not be insulated.

(f) Any equipment grounding conductor that is adequate for power circuits is more than adequate for static grounding.

19-3.13.3 Inspection and Maintenance. An inspection and maintenance program is essential in assuring that the integrity of static grounding systems is retained. Inspections should be made only by properly trained personnel. Inspections should consist of both resistance measurements and a visual check.

(a) The resistance from all conducive parts to ground should be measured with a suitable megohmmeter (*see 18-3.13.5*). Corrective measures should be made to bring all resistance values within specifications.

(b) A visual inspection should be made for frayed wires, wires with broken strands and for other physical damage. Such damage should be repaired regardless of measured resistance values.

19-3.13.4 Inspections should be made on all new installations and whenever alterations are made to or parts replaced in an installation. Inspections should be made at regular intervals.

The frequency of regular periodic inspections must be determined from experience. Inspections should be most frequent in areas where corrosion is a problem and in areas classified as hazardous.

19-3.13.5 Megohmmeters. A suitably calibrated resistance measuring device having a nominal open-circuit output voltage of 500 volts DC and a short-circuit current not exceeding 5 mA should be used to check static grounding systems. If inspections are made when flammable vapors are apt to be present, the megohmmeter should be of an intrinsically safe type.

19-3.13.6 Record-keeping. Precise records should be made and retained of the results of all inspections and of the corrective actions taken. Precise records will aid in determining the necessary inspection frequency and point out weak spots in the static grounding system which may need modification.

19-3.13.7 Precautions During Inspections. If inspections and corrective measures must be made when flammable vapors are apt to be present, certain precautions must be taken by the inspector and maintenance personnel.

(a) Care must be taken that personnel are adequately grounded to prevent a dangerous accumulation of static electricity on their bodies.

(b) Care must be taken that no spark discharge occur between improperly grounded conductors to personnel, instrumentation or tools.

(c) Only nonferrous, nonsparking tools should be used in the area.

19-3.13.8 Typical Check Points for Inspection.

(a) All conductors in a hazardous area must be inspected for adequate static grounding.

(b) Since machines and operations differ considerably, a check list should be prepared of all points to be checked. The following are typical for many machines and operations.

1. Permanently installed jumper wires.
2. Static ground wires and clamps used for the temporary grounding of portable and mobile equipment.
3. Metal hose couplings.
4. Metal hose clamps.
5. Metal bolts and nuts used to connect sections of either conductive or nonconductive pipes and ducts.
6. All sections of metal pipes and ducts.

7. Rotating parts and shafts.
8. Rotating baskets of centrifuges.
9. Handles and stems of ball valves and plug valves.

c. All rotating parts should be checked while in motion.

19-4 Process Instrumentation and Control.

19-4.1 General. The system and equipment covered by this section are the following: power supplies; interlock and logic systems; safety and shutdown systems; sensing, control and indicating systems; and alarm systems.

19-4.2 Design to Accommodate Maintenance.

19-4.2.1 Section 5-1 of this recommended practice has stated that, except for limited visual inspection such as observing operating temperatures, examination for contamination, recording load readings, etc., the apparatus must be taken out of service to perform efficient and effective maintenance. Further, unless flexibility is built into the system in the way of duplication or alternate transfer schemes, maintenance of vital electrical apparatus must be scheduled with planned production outage.

19-4.2.2 The importance of identifying and designing for the vital elements of the process control system cannot be overstressed. The elements of the process instrumentation and control system which must be inspected, tested, or maintained while the plant or process remains in operation must be identified in the design stage. The necessary duplication of facilities and provision for test and inspection should be provided.

19-4.2.3 Examples of such provisions are alternate power sources to permit shutdown and inspection of normal power sources, bypass switches for inverters, provisions for on-stream function testing of shutdown circuits, provision of dual sensing components for critical controls, test circuits to permit simulation of alarm conditions, and monitoring devices for important interlock and logic systems. Selection of quality equipment is also mentioned in Section 5-1 as a means of reducing maintenance requirements. Again, the importance for long run facilities cannot be overemphasized.

19-4.2.4 Whenever possible, control modules should be plug-in type replaceable with normal precautions and procedures. Test and adjustment of major components should be possible without disconnecting or removing from enclosures and with use of standard instruments such as, volt-ohm-milliammeter and oscilloscope.

19-4.2.5 Cabinets should be fully compartmented to allow maintenance access to sections not in service without risk to personnel or continuity of service. For instance, the inverter, standby transformer/voltage regulator and transfer switch power supply should be in physically separate compartments. Removal or replacement of components in one cabinet section should not require access to other sections.

19-4.3 Power Supplies.

19-4.3.1 Power supplies can be divided into two categories: power supplies normally in service; and standby or emergency power supplies.

19-4.3.2 Power supplies which are normally in service should be inspected on a regular basis. This inspection would include the following typical checks and inspections:

(a) Reading of meters to detect changes in or abnormal load or voltage conditions.

(b) Check of ground detection equipment for presence of grounds.

(c) Integrity of trip and transfer circuits where monitoring lights are provided.

(d) State of charge on batteries.

(e) Battery charger supply and output load and voltages.

(f) Visual inspection of accessible current carrying parts for signs of overheating.

(g) Check on equipment environment for heat, moisture, or dust which exceed the conditions for which the equipment is designed.

19-4.3.3 The inspection interval may be daily, weekly, or monthly, depending on equipment environment and operating conditions. Tasks such as reading of meters and checks on monitoring lights may be incorporated as part of a daily walk-through inspection.

19-4.3.4 Where redundancy in facilities is provided, equipment components should be taken out of service for a thorough inspection and testing and for any required maintenance at intervals dictated by service and operating conditions. The initial interval should be in line with manufacturer's recommendations and later shutdowns scheduled in line with the as-found condition of the equipment.

19-4.3.5 Where power supply components are in standby or emergency service, periodic testing should be carried out to ensure that the standby equipment is ready to function and can assume the supply function. This requires periodic startup of emergency generators, operation of auto-transfer switches, etc. Testing should simulate actual operating conditions as closely as possible. For critical facilities, testing intervals such as once a week are suggested.

19-4.3.6 Where it is possible to put critical standby facilities in operation to supply the normal load without disturbing plant operations, the standby facilities should be switched in at regular intervals and operated for a sufficient period to ensure they are functioning properly. An interval of once a month is suggested for operating standby facilities. Where standby facilities are fully rated, they may share operating time on an equal basis with the normal supply.

19-4.4 Interlock and Logic Systems.

19-4.4.1 Maintenance procedures on interlock and logic systems are limited to visual inspections of components and wiring and checks on monitoring devices unless design features permit on-stream functional testing. Also, in some plants, the process operation or equipment arrangement permits periodic function testing.

19-4.4.2 Where functional testing can be done and where the system does not function during normal operations, once a week function testing is suggested for systems whose failure can result in hazard to personnel, fire, damage to equipment or serious degradation or loss of product. Systems of lesser importance should be tested initially on a once-per-month basis with subsequent testing intervals determined by experience and assessment of operating environment.

19-4.5 Sensing, Indicating and Control Systems.

19-4.5.1 The need for and frequency of inspection and maintenance is determined by the effect on safety, plant operattions, and the severity of service. Also, some components can be readily isolated while others can be inspected only during plant or process shutdowns.

19-4.5.2 Visual inspection either by plant operators during normal operations or as part of a scheduled inspection can assist in detection of deficiencies such as loose connections, overheating, excessive vibration, etc.

19-4.5.3 Sensing, indicating and control devices can be divided into two categories:

(a) Primary Elements. Elements in contact with the process medium directly or indirectly and which may or may not be isolated from the process medium.

(b) Secondary Elements. Transmitting, recording or controlling devices. Some are normally in use and, through this use, are receiving an automatic day-to-day check. Some are remotely located or infrequently used and require a check at regular intervals.

19-4.6 Level Devices.

19-4.6.1 Primary devices installed within process vessels can only be checked with vessel out of service. Visual inspection should indicate need for maintenance.

19-4.6.2 Where the device can be isolated from the process, visual inspection should be made at least once a year and more frequently if extreme accuracy is needed or the service is severe or critical.

19-4.7 Temperature Devices.

19-4.7.1 Primary devices are generally installed in wells and can be checked at any time the device appears to be malfunctioning. The well should be visually inspected at each plant shutdown and necessary maintenance carried out.

19-4.7.2 The secondary device or instrument can usually be checked at any time without seriously affecting normal operations.

19-4.8 Pressure Devices.

19-4.8.1 Primary devices usually have block valves to permit isolation from the process and check at any time malfunction is indicated.

19-4.8.2 Secondary devices can usually be isolated from the primary device and checked at any time.

19-4.8.3 Process impulse connections should be checked during equipment shutdown.

19-4.9 Indicating, Recording and Controlling.

19-4.9.1 Signal Receivers. Checks are limited to day-to-day observation of performance by plant operators. Receiver construction usually permits substitution of spare units for faulty units.

19-4.10 Safety and Shutdown Systems.

19-4.10.1 On-line testing facilities for safety and shutdown systems should be provided in all designs. Where practical, the facilities should include multiple sensors and safe bypass systems around the final control element. This permits testing of the entire shutdown circuit.

19-4.10.2 Safety and shutdown circuits should be tested in the range of one-per-shift to once-per-week unless the circuit functions regularly in normal operation. This may be the case for some shutdown circuits.

19-4.10.3 Because of the frequency of testing, these functional tests may be part of the plant operators normal duties with maintenance personnel involved only if problems are indicated.

19-4.11 Alarm Systems.

19-4.11.1 Alarm systems are usually equipped with lamp test switches which permit checking lamp and alarm circuit integrity at any time during normal operation. These tests should be made on a once-per-shift to once-per-day basis to detect lamp burnout or circuit defects in alarms which operate infrequently. This can be done as part of the plant operators normal duties with maintenance personnel involved only if further attention is needed.

19-4.11.2 Alarms for critical conditions which may result in hazard to personnel, fire, equipment damage, or serious degradation or loss of product should be function-tested at regular intervals. A once-per-week to once-per-month interval is suggested depending on the importance and vulnerability of the alarm devices to hostile environments. Function testing requires that either provision be made in the system design for the testing facilities or that it be possible to test by manipulating the process variable or otherwise simulate the alarm conditions.

19-4.12 Wiring Systems.

19-4.12.1 These systems can be visually checked for loose connections, proper grounding and shielding and for signs of deterioration or corrosion. Usually maintenance during plant operation is limited to circuits which malfunction or show evidence of possible malfunction.

26. Revise Appendix A, Bibliography, as follows:

Add to American National Standards Institute list the following:

American National Standard Safety Standard for the Lockout/Tagout of Energy Sources — ANSI Z244.1–1974.

Guidelines for Handling and Disposal of Capacitor- and Transformer-Grade Askarels Containing Polychlorinated Biphenols — ANSI C107.1–1974.

Correct Institute of Electrical and Electronics Engineers titles as follows:

Recommended Practice for Electric Power Distribution in Industrial Plants — IEEE No. 141 (Red Book).

Recommended Practice for Electric Power Systems in Commercial Buildings — IEEE No. 241 (Gray Book).

Add to Institute of Electrical and Electronics Engineers list the following:

Recommended Practice for Grounding of Industrial and Commercial Power Systems — IEEE No. 142 (ANSI C114.1, 1973 [Green Book]).

Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems — IEEE No. 242 (Buff Book).

Recommended Practice for Emergency and Standby Power Systems for Industrial Plants — IEEE No. 446 (Orange Book).

Guide for Protective Relaying of Utility-Consumer Interconnection — IEEE 357.

Testing Insulation Resistance of Rotating Machinery — IEEE No. 43 (ANSI C50–22).

Insulation Maintenance Guide for Rotating Electrical Machinery Rated from 5 to 10,000 HP — IEEE No. 432.

Guide for AC Motor Protection — IEEE No. 588 (ANSI C37.96).

Add to National Electrical Manufacturers Association list the following:

Safe Handling, Installation, Operation and Maintenance of Switchboard — NEMA No. PB 2.1–1975.

Safe Installation, Operation and Maintenance of Panelboards — NEMA No. PB 1.1–1975.

27. Appendix B, Receptacle Outlets, delete "Three-pole" *from the first sentence.*

28. Add new Appendix G-1 as shown on Page 34.

Appendix G-1

NEMA CONFIGURATIONS FOR GENERAL-PURPOSE NONLOCKING PLUGS AND RECEPTACLES

		15 AMPERE		20 AMPERE		30 AMPERE		50 AMPERE		60 AMPERE	
		RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG
2-POLE 2-WIRE	1 125 V	 1-15R	 1-15P								
	2 250 V		 2-15P	 2-20R	 2-20P	 2-30R	 2-30P				
	3 277 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
	4 600 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
2-POLE 3-WIRE GROUNDING	5 125 V	 5-15R	 5-15P	 5-20R	 5-20P	 5-30R	 5-30P	 5-50R	 5-50P		
	6 250 V	 6-15R	 6-15P	 6-20R	 6-20P	 6-30R	 6-30P	 6-50R	 6-50P		
	7 277 V AC	 7-15R	 7-15P	 7-20R	 7-20P	 7-30R	 7-30P	 7-50R	 7-50P		
	24 347 V AC	 24-15R	 24-15P	 24-20R	 24-20P	 24-30R	 24-30P	 24-50R	 24-50P		
	8 480 V AC	(RESERVED FOR FUTURE CONFIGURATIONS)									
	9 600 V AC	(RESERVED FOR FUTURE CONFIGURATIONS)									

3-POLE 3-WIRE	10 125/250 V			10-20R	10-20P	10-30R	10-30P	10-50R	10-50P		
	11 3 ϕ 250 V	11-15R	11-15P	11-20R	11-20P	11-30R	11-30P	11-50R	11-50P		
	12 3 ϕ 480 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
	13 3 ϕ 600 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
3-POLE 4-WIRE GROUNDING	14 125/250 V	14-15R	14-15P	14-20R	14-20P	14-30R	14-30P	14-50R	14-50P	14-60R	14-60P
	15 3 ϕ 250 V	15-15R	15-15P	15-20R	15-20P	15-30R	15-30P	15-50R	15-50P	15-60R	15-60P
	16 3 ϕ 480 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
	17 3 ϕ 600 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
4-POLE 4-WIRE	18 3 ϕ 208Y/120 V	18-15R	18-15P	18-20R	18-20P	18-30R	18-30P	18-50R	18-50P	18-60R	18-60P
	19 3 ϕ 480Y/277 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
	20 3 ϕ 600Y/347 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
4-POLE 5-WIRE GROUNDING	21 3 ϕ 208Y/120 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
	22 3 ϕ 480Y/277 V	(RESERVED FOR FUTURE CONFIGURATIONS)									
	23 3 ϕ 600Y/347 V	(RESERVED FOR FUTURE CONFIGURATIONS)									

29. Add new Appendix G-2 as follows:

Appendix G-2

NEMA CONFIGURATIONS FOR LOCKING PLUGS & RECEPTACLES

			15 AMPERE		20 AMPERE		30 AMPERE	
			RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG
2-POLE 2-WIRE	125 V	L1	L1-15R	L1-15P				
	250 V	L2			L2-20R	L2-20P		
	277 V AC	L3	F	U	T	U	R	E
	600 V	L4	F	U	T	U	R	E
2-POLE 3-WIRE GROUNDING	125 V	L5	L5-15R	L5-15P	L5-20R	L5-20P	L5-30R	L5-30P
	250 V	L6	L6-15R	L6-15P	L6-20R	L6-20P	L6-30R	L6-30P
	277 V AC	L7	L7-15R	L7-15P	L7-20R	L7-20P	L7-30R	L7-30P
	480 V AC	L8			L8-20R	L8-20P	L8-30R	L8-30P
	600 V AC	L9			L9-20R	L9-20P	L9-30R	L9-30P
3-POLE 3-WIRE	125/250 V	L10			L10-20R	L10-20P	L10-30R	L10-30P
	3Ø 250 V	L11	L11-15R	L11-15P	L11-20R	L11-20P	L11-30R	L11-30P
	3Ø 480 V	L12			L12-20R	L12-20P	L12-30R	L12-30P
	3Ø 600 V	L13					L13-30R	L13-30P
3-POLE 4-WIRE GROUNDING	125/250 V	L14			L14-20R	L14-20P	L14-30R	L14-30P
	3Ø 250 V	L15			L15-20R	L15-20P	L15-30R	L15-30P
	3Ø 480 V	L16			L16-20R	L16-20P	L16-30R	L16-30P
	3Ø 600 V	L17					L17-30R	L17-30P
4-POLE 4-WIRE	3Ø 208Y/120 V	L18			L18-20R	L18-20P	L18-30R	L18-30P
	3Ø 480Y/277 V	L19			L19-20R	L19-20P	L19-30R	L19-30P
	3Ø 600Y/347 V	L20			L20-20R	L20-20P	L20-30R	L20-30P
4-POLE 5-WIRE GROUNDING	3Ø 208Y/120 V	L21			L21-20R	L21-20P	L21-30R	L21-30P
	3Ø 480Y/277 V	L22			L22-20R	L22-20P	L22-30R	L22-30P
	3Ø 600Y/347 V	L23			L23-20R	L23-20P	L23-30R	L23-30P

30. Add new Appendix H as follows:

Appendix H Long-term Maintenance Guidelines

H-1 Introduction. This appendix deals specifically with the maintenance of equipment which by nature of its application necessitates long intervals between shutdowns. It should be stressed that environmental or operating conditions of a specific installation must be considered and may dictate a different frequency of maintenance than suggested in this appendix.

H-2 Medium Voltage.

1. Cables.
2. Liquid-filled Transformers.
3. Dry-type Transformers.
4. Metal-clad Switchgear.
5. Circuit Breakers.
6. Metal Enclosed Switches.
7. Buses and Bus Ducts.
8. Protective Relays.
9. Automatic Transfer Control Equipment.
10. Fuses.
11. Lightning Arresters.

H-3 Medium and Low Voltage Equipment.

1. Outside Overhead Electric Lines.

H-4 Low Voltage Equipment.

1. Low Voltage Cables and Connections.
2. Dry-type Transformers.
3. Switchgear.
4. Draw-out Type Circuit Breakers.
5. Buses and Bus Ducts.
6. Panelboards.
7. Protective Relays.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 1-Cables, Terminations and Connections

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Solid Dielectric (Chapter 8)	**Inspections (while energized) of** (8-2.1):	One year.
	Conduit entrances (8-4).	Observe for deformation due to pressure and for bends with radius less than minimum allowed.
	Poles and supports.	Ditto.
	Binder tape terminations (aerial cables) (8-3).	Ditto.
	Ends of trays (8-4).	Ditto.
	Splices (8-2.3).	Ditto.
	Terminations (stress cones and potheads) (8-2.3) (8-2.5).	Ditto plus dirt, tracking, water streaks, chipped porcelain, shield ground connections (where visible) and adequate clearances from grounded metal parts.
	Fireproofing (where required) (8-2.3).	Observe for continuity.
	Loading.	Make certain loads are within cable ampacity rating.
Varnished Cambric Lead Covered and Paper Insulated Lead Covered	**Inspections (while energized) of** (8-2.1):	
	Same as above.	Same as above.
	Lead sheath (8-2.3).	Observe for cracks or cold wipe joints — often indicated by leakage of cable oil or compound.
All Types	**Major Maintenance and Testing (de-energized)** (5-3) (8-2.1):	Three to six years.
	Complete inspection same as above.	Same as above.
	Clean and inspect porcelain portions of potheads (8-2.5) (6-1.2.1).	For cracks and chips.
	Clean and inspect stress cones and leakage sections (8-2.3) (6-2.13).	For soundness of stress cones. X-ray or disassemble, if soft spots are detected. For surface tracking.
	Check plastic jackets for longitudinal shrinkage from splices and terminations.	Jacket shrinkage might have damaged shielding tapes or stress cones.
	Check integrity of shield grounding (8-2.3).	Observe ground connections for stress cones. Suggest checking electrical continuity of shielding tape.
	Check general condition of cable (8-2.3).	Does insulating material appear to have been damaged by overheating?
	Observe connectors for overheating (8-2.5) (6-1.3) (6-2.14).	Discoloration and/or oxidation indicate possible problem. Check bolts for tightness, if accessible. If connectors are insulated with tape, deterioration or charring of tape is indicative of overheated connector, caused by loose bolts, etc. Infrared survey while conductors are energized and loaded to at least 30 percent of ampacity may be beneficial to detect overheated connections. Use good quality infrared scanning equipment.
	Test cable insulation with high potential DC (8-5) (18-9.1).	Disconnect cables from equipment and provide corona protection on ends. Ground other conductors not being tested. Record leakage current in microamperes at each test voltage level. Record temperature and relative humidity.
	Determine condition of cable insulation (18-9.2.4.3).	Interpret test results, considering length of cable, number of taps, shape of megohm or leakage current curve, temperature and relative humidity.
	Reconnect cables to equipment. Aluminum conductors.	Tighten connectors adequately. Make certain that connectors of the proper type are correctly installed. Use Belleville washers when bolting aluminum cable lugs to equipment. Advisable to determine conductivity of connection using microhmmeter or determine voltage drop under test load conditions. (18-12).

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 2-Liquid-filled Transformers

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
(Oil and Askarel) Sealed Tank, Conservator and Gas Sealed Systems (Chapter 7)	**Inspections (while energized) of:**	
	Top liquid temperature (7-2.4).	Weekly to monthly. Record findings. Present temperature and highest indicated. Reset drag needle. 80°C nominal max. permitted.
	Head space pressure (sealed tank type) (7-2.5.2).	Should vary under changes in loading and ambient temperature. If gauge remains at zero, gauge is broken or leak exists in tank head space which permits transformer to breathe and allows entrance of moisture.
	Nitrogen pressure (pressurized tank type).	Check nitrogen bottle pressure and pressure in transformer head space.
	Liquid level in tanks (7-2.5.1).	Should be between min. and max. marks on gauge.
	Liquid levels in oil-filled bushings (if so equipped).	Should be between min. and max. marks on gauge.
	Evidence of oil leaks (7-2.7.4).	From tanks, fittings, cooling tubes and bushings.
	Automatic load tap changer mechanism.	General condition; note and record number of operations.
	Tests (while energized) of:	
	Oil — draw sample and test in laboratory for (7-2.8) (7-2.8.6).	Biannually for rectifier and arc furnace transformers. Dielectric strength, acidity, and color. If dielectric is low, determine water content. Annually for normal service transformers.
	Askarel — draw sample and test in laboratory for (7-2.8) (7-2.8.6). (Observe EPA regulations for handling and disposal.)	Same frequency as for oil. Dielectric strength, acidity, color, and general condition. If dielectric is low determine water content.
	Comprehensive liquid tests (7-2.8.6).	Frequency three to six years. In addition to above, tests include interfacial tension, water content, refractive index power factor at 25° and 100°C (18-9.3.2) corrosive sulphur (Askarel), and inclusion of cellulose material.
	Dissolved gas content in liquid of transformers in critical service or in questionable condition as might be indicated by above liquid tests (18-16).	Frequency six years or as conditions indicate. Draw sample in special container furnished by test laboratory. Spectrophotometer test will detect gases in oil caused by certain abnormal conditions in transformer. A series of tests on samples drawn over period of time may be necessary to determine if abnormal condition exists and to determine problem. Devices are available for installation on transformers to collect gases to be tested for combustibility to determine if internal transformer problem exists.
	Major Maintenance and Tests (de-energized) (5-3) (7-2.7.2):	Three to six years or more often if above tests indicate.
	Make above tests well in advance of scheduled shutdown.	Determine possible problems that require attention.
	Inspect pressure relief diaphragm for cracks or holes or mechanical pressure relief device for proper operation (7-2.7.3).	Replace if defective.
	Pressure test with dry nitrogen the head space areas of sealed type transformers if pressure gauge remains at zero and pressure relief device is satisfactory.	Possible cause of pressure in sealed type transformers remaining at zero. Apply liquid along seams, etc., to locate leaks. Make necessary repairs.
	Clean bushings and inspect surfaces (7-2.7.3).	Consider application of silicone grease in badly contaminated areas. Should be removed and reapplied at maximum two-year intervals, preferably one year.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 2-Liquid-filled Transformers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
(Oil and Askarel) Sealed Tank, Conservator and Gas Sealed Systems (Cont.)	**Major Maintenance and Tests (de-energized) (Cont.):**	
	Inspect load tap changer mechanism and contact.	Follow manufacturer's instructions on maintenance and number of operations between contact replacements.
	Paint tank as required.	Wire-brush rust spots and prime paint. Finish paint.
	Check ground system connections (7-2.7.5).	
	Perform turns ratio tests (18-11).	In each tap position. As an acceptance test and after major repairs.
	Perform power factor tests (disconnect from equipment) (18-9.3.2).	Windings, bushings and insulating liquid.
	Consider making winding/tap changer resistance tests.	Use microhmmeter. In each tap position to detect abnormally high contact resistance.
	Make undercover inspection through manholes (provide positive protection to prevent entrance of moisture) (7-2.7.6). This inspection may not be necessary at six-year intervals unless tests indicate problems.	Six-year frequency should definitely be considered for rectifier and arc furnace transformers. Inspect for moisture or rust under cover, water on horizontal surfaces under oil, tap changer contacts (insofar as possible), trash, oil sludge deposits, loose bracing and loose connections.
	Consider high-potential DC tests (7-2.9.4) (18-5 through 18-8).	DC in excess of 34 kV may polarize liquid and thereby increase leakage currents.
	If above inspections and/or tests indicate possible internal problems, it may be necessary to transport transformer to shop to untank the core and coil assembly for cleaning, inspecting, testing and making repairs as found necessary.	
	Filtering insulating liquid (de-energize transformer and ground windings) (7-2.8.6.3).	Frequency as required. Remove moisture by heating and pumping liquid through cellulose filters, a centrifuge or a vacuum dehydrator. Thoroughly clean hoses and filtering equipment before switching from oil to Askarel or vice versa (7-2.1.2). Observe ANSI C107.1, 1974 for handling and disposal of Askarel.
	Re-refining insulating oil (de-energize transformer and ground windings) (7-2.8.6.3).	Frequency as required. Filter through fuller's earth to remove polar compounds and acids. Add dibutylparacresol to replace oxidation inhibitors.
	Refilling transformer with insulating liquid (7-2.7.7 & 7-2.7.8).	Refill under partial vacuum if transformer tank is so designed. Follow manufacturer's instructions. Always test insulating liquid for dielectric strength (min. 26 kV for oil) prior to pumping into transformer and pump through filter (min. 30 kV Askarel).
	Special Testing (de-energized):	
	Induced potential test (7-2.9.5).	To test phase-to-phase and turn-to-turn insulation. (200 to 300 Hz for 7200 volt cycles). Proof test.
	AC high potential test (18-9.3.1).	Proof test.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns,— Electrical Distribution, H-2 Medium Voltage Equipment, 3 Dry-type Transformers

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Ventilated (Indoors) (7-1 & 7-3)	**Inspections (while energized) of:**	Weekly to monthly. Record findings.
	Operating temperature (7-3.4).	Present temperature and highest indicated. Reset drag needle. 150°C is max. operating temperature for transformers rated 80°C rise. 220°C is max. operating temperature for transformers rated 150°C rise.
	Cleanliness of screens located over or behind ventilation louvers in enclosure (7-3.6).	Clogged screens restrict ventilation and thereby increase operating temperature of core and coil assembly. Vacuum screens without de-energizing transformer if dust and lint are on outside of screens. If same is on inside, transformer must be de-energized and enclosure sides removed to clean screens.
	Ventilating fan operation (if so equipped.)	Check operation of fans with control switch in "Manual" position. Do not operate fans continuously with switch in "Manual"; leave in "Automatic" so temperature detectors will operate fans at temperatures above specified levels. Also check alarm contacts for proper operation at excessive temperature levels.
	Room ventilation (7-3.6).	Adequate ventilation system to admit and exhaust air. Air streams should not be directed toward upper vent louvers in transformer enclosure because it will restrict ventilation inside transformer and cause overheating.
	Evidence of condensation and water leaks in room (7-3.6).	Inspect top of transformer. Make necessary corrections.
	Major Maintenance (de-energized) (7-3.7) (5-3):	Three to six years. More often if required.
	Remove enclosure covers and clean vent louvers and screens (7-3.7.2).	
	Clean insulators, core and windings (7-3.7.2 & 7-3.7.3).	Use bottle of dry nitrogen with pressure regulator, hose and small nozzle to blow off dust. Restrict pressure to 30 psi max. Clean with soft bristle brush as required.
	Inspect following components:	
	Interphase barriers (7-3.7.2).	Should not touch windings.
	Wedges and clamping rings (7-3.7.2).	For proper clamping of windings. Tighten as required.
	Primary and secondary buses and conductors (7-3.7.2) (6-1.3).	For tightness of connections.
	Porcelain insulators (6-1.2).	For chips, cracks and water steaks.
	Insulating materials (7-3.7.2) (6-2.10 through 6-2.14).	For surface tracking.
	Windings (7-3.7.2) (6-2.14) (7-3.7.3).	For damage to insulation, including overheating.
	Tap connections (7-3.7.2).	For tightness and correctness to provide proper voltage.
	Core assembly.	For loose and/or dislocated laminations, localized or general overheating and for integrity of ground strap which is *only* place where core assembly is permitted to be grounded.
	Ventilating channels between core and windings and between windings (7-3.7.3).	For clogging with lint, dust or tape used to hold spacers, etc., in place during assembly. Clean as required to allow proper air flow.
	Space heaters for proper operation.	Used to keep windings dry when transformer is de-energized.
	Temperature detectors.	For proper location and proper support of leads.
	Temperature indicators.	For accuracy and operation of fan and alarm contacts at proper temperatures.
	Cooling fans.	For free turning and proper operation.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 3 Dry-type Transformers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Ventilated (Indoors) (Cont.)	**Testing (de-energized)** (18-1) (18-4 through 18-8):	Three to six years. More often if required.
	Turns ratio test (18-11).	In each tap position as an acceptance test and after major repairs.
	Polarization index test (7-2.9.1) (7-2.9.2 & 7-2.9.3) (18-9).	Use 1000 volt insulation resistance tester. Low P.I. results often indicates moisture in winding. If so, investigate cause and satisfactorily dry transformer before making high potential DC test and returning transformer to service.
	High potential DC test (7-2.9.4) (18-9.2.4).	Record leakage currents in microamperes, temperature and relative humidity.
	Special Testing (de-energized):	
	Induced potential test (7-2.9.5).	To test phase-to-phase and turn-to-turn insulation. (200 to 300 Hz. for 7200 volt cycles.) Proof test.
	AC high potential test (18-9.3.1).	Proof test.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 4-Metal-clad Switchgear

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor (Chapter 6)	**Inspections (while energized):**	Three to six months.
	Open external doors and inspect components:	
	Fronts of circuit breakers.	Record number of operations.
	Protective and control relays (6-8.7).	Wiring and connections — not internals.
	Auxiliary devices, wiring and terminal blocks (6-4.6).	Proper indicating lights should light.
	Space heaters (6-2.7).	Operate continuously to overcome possible malfunction of thermostats. Consider installation of ammeters in heater supply circuits to monitor full load current of heaters on each circuit to assure that all are operating.
	Ventilation (6-2.8).	Ventilation louvers should be open.
	Insulators and insulating materials (6-2.10 through 6-2.14).	
	Cable terminations (8-1 through 8-4).	Observe stress cones and leakage sections annually for cleanliness and tracking.
	Batteries (6-8.4).	
	Also inspect for following conditions:	
	Loading.	Record loads.
	Cleanliness (6-2.9).	Moderate amount of dry nonconductive dust not harmful.
	Dryness (6-2.5 & 6-2.6).	Evidence of condensation or water leaks.
	Rodents and reptiles (6-2.4).	
	Overheating of parts (6-2.14).	Discoloration and/or oxidation indicate possible problem.
	Tracking on insulating surfaces (6-2.13).	Take necessary corrective action.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 4-Metal-clad Switchgear (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor (Cont.)	**Major Maintenance or Overhaul:**	Three to six years, depending on ambient conditions.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Completely clean, inspect, tighten and adjust all components (6-4.1):	Follow manufacturer's maintenance instructions.
	Structure and enclosure (6-2.3 & 6-2.4).	Wire-brush and prime paint rust spots. Finish paint.
	Ventilating louvers and air filters (6-2.8).	Clean or replace filters as required.
	Buses, splices and bolts (6-1.3) (6-2.14).	Check bolts for manufacturer's recommended torque. If inaccessible, check insulating tape, boot or compound box over bus splices for heat deterioration due to loose bolts, etc.
	Insulators and insulating materials (6-2.10 through 6-2.14) (6-1.2).	Clean and inspect for surface tracking.
	Circuit breakers (6-4 through 6-6).	Refer to Oil and Air Circuit Breaker sections.
	Breaker disconnect studs and finger clusters (6-4.3.7).	Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Draw-out breaker racking mechanisms (6-1.7).	Alignment and ease of operation.
	Cable terminations and connections (8-1 through 8-4).	Clean and inspect for surface tracking. Check connections for tightness.
	Meters (6-8.7).	Test for accuracy.
	Controls, interlocks and closing power rectifiers (6-8.8).	Make functional tests.
	CT's, PT's and control power transformers (6-8.5).	Check voltages.
	Fuse clips and fuses (13-2).	Check clips for adequate spring pressure.
	Grounding (6-1.5) (6-8.9).	Proper fuse rating.
	Components and conditions in above block.	Make necessary repairs.
	Testing (Chapter 18) (5-3):	Three to six years, depending on ambient conditions.
	Test buses, breakers, PT's, CT's and cables with high potential DC.	Record leakage currents in microamperes (18-9.2.4) (8-5).
	Calibrate and test protective relays (18-10.3).	Refer to Protective Relays section.
	Functionally trip breakers with relays (18-10.3.2.7).	Preferably, inject test current into CT and relay circuits.
	Test conductivity of aluminum cable connections (18-12) (6-1.3).	Use microhmmeter or determine voltage drop under test load conditions.
	Test wiring for controls, meters and protective relays for insulation resistance (18-9.2.1).	1000 volt DC for control wiring. 500 volt DC for meters and relays.
Outdoor	**Inspections (while energized):** Same as for indoor gear except:	One to three months.
	Special emphasis on evidence of condensation and water leaks (6-2.3) (6-2.5) (6-2.6).	Rust spots on underside of metal roof indicative of condensate.
	Special emphasis on space heater operation (6-2.7).	
	Ventilating louvers and air filters and cleanliness (6-2.8).	Clean or replace air filters as required.
	Major Maintenance or Overhaul:	Three years. More often if conditions require.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Same as for indoor gear.	Follow manufacturer's maintenance instructions.
	Testing (Chapter 18) (5-3): Same as for indoor gear.	Three years. More often if conditions require.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 5-Circuit Breakers

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Air-break, Draw-out Type (6-4)	**Inspection and Maintenance (withdrawn from switchgear and de-energized)** (5-3):	Max. of three years or at manufacturer's maximum number of operations since previous maintenance, whichever occurs first. Immediately after breaker opens to interrupt a serious fault. Follow manufacturer's maintenance instructions. If breaker is stored energy closing type, follow manufacturer's safety precautions, determine that closing springs are discharged, or mechanism is blocked to prevent personal injury. Keep hands away from contacts and mechanism while test operating breaker (6-4.1.1).
	Remove arc chutes. Inspect, adjust and clean where necessary:	
	Main contacts (6-4.3).	For pitting, spring pressure, overheating, alignment, overtravel or wipe. Adjust or replace accordingly.
	Arcing contacts (6-4.3.2).	For alignment, overtravel or wipe and for arc erosion. Adjust or replace accordingly.
	Moving parts and linkages (6-4.5.1 through 6-4.5.3).	For freedom of movement.
	Closing mechanism (6-4.5).	For quick and positive closing action.
	Tripping mechanism (6-4.5).	For freedom of movement and reliability to open breaker contacts.
	Interlocks and safety devices (6-8.8) (6-4.6.2).	Functionally test to prove proper operation.
	Primary disconnect finger clusters (6-4.3.7).	For proper adjustment and spring pressure. Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Secondary disconnect contacts (6-4.3.7).	For alignment and spring pressure. Lubricate.
	Closing and trip coils (6-4.6.1.)	General condition and evidence of overheating.
	Spring charging motor and mechanism (stored energy type) (6-4.6.1).	Proper operation. Oil leaks from gear motor.
	Shunt trip device (6-4.6.1).	For freedom of movement. Functionally test.
	Undervoltage trip device.	For freedom of movement. Functionally test.
	Auxiliary contacts.	For proper operation with closing and opening of breaker.
	Closing (x and y) relays (electrically operated breakers).	Contact erosion. Dress or replace as required.
	Current transformers (6-8.7.2) (6-2.10).	General condition. Check nameplate ratio.
	Connection bolts (9-3.1 through 9-3.3).	Check for tightness.
	Structure or frame.	For proper alignment and loose or broken parts.
	Fuses and mountings (13-1 & 13-2).	General condition and tightness.
	Frame grounding device.	Connect before and disconnect after primary fingers.
	Position indicators (6-4.6.2) (6-8.6.2).	For proper operation.
	Auxiliary wiring.	General condition and tightness of terminal screws.
	Arc chutes (6-4.4).	For broken parts, missing arc splitters, and amount of metal spatter and burning on interior surfaces. Snuffer screens must be clean. Repair or replace as necessary.
	Operation counter.	For proper operation. Record number of operations.
	Insulators and insulating materials (6-2.10, 6-2.12 & 6-2.13) (6-4.2).	For cracks, breaks, corona, tracking and overheating.
	Breaker auxiliary devices (6-4.6).	Make necessary repairs.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 5-Circuit Breakers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Air-break, Draw-out Type (Cont.)	**Testing (withdrawn from switchgear and de-energized)** (5-3) (18-5; -6; -7 & -8):	Max. of three years, etc., same as above block.
	Insulation (18-9.1) (18-9.2.1) (18-9.2.2) (18-9.2.4).	High-potential test each main contact with breaker open and all other main contacts and frame grounded. Record results. Use 1000 volt megohmmeter on auxiliary devices, controls and associated wiring.
	Contact conductivity or resistance (18-12).	Use microhmmeter or determine voltage drop under test load conditions.
	System Testing (breaker installed):	
	Electrically operated breaker.	After above maintenance and testing has been satisfactorily completed, install electrically operated breaker in proper switchgear cell and rack it into "TEST" position, or, when test stand (station) is provided, connect breaker control contacts to same with cord and plug provided with breaker. Operate closing control devices to assure that breaker closes and latches without trip-free operations. Operate trip control devices to assure that breaker trips open in a reliable manner. (6-4.6.3). Functionally test all electrical interlock and safety devices. After satisfactorily passing all operational tests, the breaker may be racked into the "CONNECTED" position and placed in normal service.
Oil-immersed, Draw-out Type (6-6)	**Inspection and Maintenance (withdrawn from switchgear and de-energized)** (5-3):	Max. of three years or at manufacturer's maximum number of operations since last previous maintenance, whichever occurs first. Immediately after breaker opens to interrupt a serious fault. Follow manufacturer's maintenance instructions.
	Lower oil tank. Inspect, adjust and clean where necessary:	
	Main contacts (6-6.3).	For pitting, spring pressure, overheating, alignment, overtravel or wipe. Adjust or replace accordingly.
	Arc-quenching assemblies (6-6.4).	For alignment, overtravel or wipe and for arc erosion. Adjust or replace accordingly.
	Moving parts and linkages (6-4.5.1 through 6-4.5.3).	For freedom of movement.
	Closing mechanism (6-4.5).	For quick and positive closing action.
	Tripping mechanism (6-4.5).	For freedom of movement and reliability to open breaker contacts.
	Interlocks and safety devices (6-8.8) (6.4.6.2).	Functional test to prove proper operation.
	Primary disconnect finger clusters (6-4.3.7).	For proper adjustment and spring pressure. Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Secondary (control) disconnect contacts (6-4.3.7).	For alignment and spring pressure. Lubricate.
	Closing and trip coils (6-4.6.1).	General condition and evidence of overheating
	Shunt trip device (6-4.6.1).	For freedom of movement. Functionally test.
	Undervoltage trip device.	For freedom of movement. Functionally test.
	Bushings (6-6.2.1).	Cracked and chipped porcelain. Condition of surfaces.
	Auxiliary contacts.	For proper operation with closing and opening of breaker.
	Closing (x and y) relays (electrically operated breakers).	Contact erosion. Dress or replace as required.
	Current transformers (6-8.7.2) (6-2.10).	General condition. Check nameplate ratio.
	Connection bolts (9-3.1 through 9-3.3).	Check for tightness.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 5-Circuit Breakers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Oil-immersed, Draw-out Type (Cont.)	**Inspection and Maintenance (withdrawn from switchgear and de-energized):**	
	Structure or frame.	For proper alignment and loose or broken parts.
	Fuses and mountings (13-1 & 13-2).	General condition and tightness.
	Frame grounding device.	Connect before and disconnect after primary fingers.
	Position indicators (6-4.6.2) (6-8.6.2).	For proper operation.
	Auxiliary devices (6-6.6).	
	Auxiliary wiring.	General condition and tightness of terminal screws.
	Arc quenchers (6-6.4).	For broken and missing parts and amount of metal spatter and burning on interior surfaces. Repair or replace as necessary.
	Operation counter.	For proper operation. Record number of operations.
	Insulators and insulating materials (6-6.2.1).	For cracks, breaks and chips.
	Insulating oil (6-6.2.2 through 6-6.2.4) (18-17) (7-2.8).	For level, general condition, dielectric strength and acidity. Make necessary repairs.
	Testing (withdrawn from switchgear and de-energized) (5-3) (18-5 through 18-8):	Max. of three years, etc., same as above block.
	Insulation (18-9.1) (18-9.2.1) (18-9.2.2) (18-9.2.4.1).	High-potential test each main contact with breaker open and all other main contacts and frame grounded. Use 1000 volt insulation resistance tester on auxiliary devices and controls and associated wiring. Test oil for dielectric strength. Clean tank and breaker mechanism. Filter oil or replace as required (6-6.2.4).
	Contact conductivity or resistance (18-12).	Use microhmmeter or determine voltage drop under test load conditions.
	DC high potential and/or power factor test (18-9.1) (18-9.2) (18-9.3.2).	Record results.
	Overcurrent trip devices (electromechanical type) on breakers so equipped (6-4.6.4).	Pass specified currents from current test set through coils of trip devices to open breaker contacts within time limits according to manufacturer's or specially designed time-current coordination curves. Adjust trip devices as required to accomplish desired results. Test set should be equipped with cycle counter for accuracy of instantaneous trip tests. Record results.
	System Testing (breaker installed): Electrically operated breaker.	After above maintenance has been satisfactorily completed, connect electrically operated breaker to switchgear or test stand control wiring by means of the test cord and plug. Operate closing control devices to assure that breaker closes and latches without trip-free operations. Operate trip control devices to assure that breaker trips open in a reliable manner (6-4.6.3). Functionally test all electrical interlock and safety devices. After satisfactorily passing all operational tests, the breaker may be placed in its switchgear cell and be racked into the "CONNECTED" position, and placed in normal service.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 5-Circuit Breakers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Air-break and Oil-immersed, Fixed Type (6-4.1.2)	**Maintenance and Testing:**	
	Open all disconnect switches to isolate main contacts from electrical supply and load wiring (5-3). **Verify that no parts of the power or control circuitry are energized by "backfeed" from alternate power or control sources.** Open closing and tripping power switches to de-energize control devices and wiring (6-1.4.1) (6-1.4.3).	Same frequencies as similar draw-out type breaker preceding. Use adequate safety procedures.
	Perform maintenance and test work in accordance with applicable portions of preceding sections.	Follow manufacturer's instructions.
	Close switches to restore closing and tripping power. Functional test controls and protective relays for proper operation of breaker.	
Pneumatically and Hydraulically Operated Type (Usually Fixed, Outdoor Type)	**Inspection (while energized):**	Monthly. Follow manufacturer's instructions.
	Check for proper air or hydraulic pressure in storage tank for closing mechanism.	
	Operate motor driven compressor.	
	Check interior of control cabinet for evidence of water leaks and condensation (6-2.5) (6-2.6).	
	Check space heater for proper operation (6-2.6.3) (6-2.7).	
	Check machined parts of mechanism for rust spots.	Should be covered with thin coat of lubricant.
	Check operation counter.	Record number of operations.
	Check control battery (6-8.4).	
	Check oil gages on high voltage bushings and breaker tanks (6-6.6).	For proper oil level.
	Porcelain bushings (6-6.2.1).	For cracks, chips and breaks.
	Insulating oil (6-6.2.2 through 6-6.2.4) (18-17) (7-2.8).	For level, general condition, dielectric strength and acidity.
	Check oil level in compressor crank case.	
	Inspect control wiring for evidence of damage.	
	Inspect breaker tanks for evidence of oil leaks.	
	Inspect breaker tanks for rust spots.	Make necessary repairs.
	Maintenance and Testing (while de-energized) (5-3):	Follow manufacturer's instructions and proper safety procedures.
	Same as applicable portions of preceding sections plus:	
	Complete check of pneumatic or hydraulic operating mechanism.	
	Power factor test.	Record results.
	On some breakers timing of contact closing and opening may be required (18-14).	Use circuit breaker time-travel analyzer or electronic timer.
	Measure contact resistance.	
	Measure contact penetration.	
	Measure resistance of internal resistors.	
	Check lever systems, stops and adjustments.	
	Check dashpot or shock absorber operation.	
	Inspect contact interrupting plates.	
	Inspect gaskets, joints, conduit and tank fittings.	
	Check pressure switch operation.	
	Check for loose bolts, tightness of joints, etc.	Make necessary repairs.
Vacuum and Gas Filled Type (6-5)	**Inspections, Maintenance and Tests:**	
	Follow manufacturer's instructions.	Under certain conditions, high potential testing can cause X-ray emission from vacuum bottles. Use manufacturer's recommended safety precautions.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 6-Metal Enclosed Switches

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor Air (6-1.4) (6-3) (6-7)	**Inspections:**	Six months.
	Observe components visible through inspection windows (if provided):	
	Switch contacts (6-2.14).	
	Auxiliary devices, wiring and terminal blocks.	
	Fuse clips and fuses (13-2).	
	Insulators and insulating materials (6-1.2) (6-2.10 through 6-2.14).	
	Space heaters (6-2.7).	Operate continuously to overcome possible malfunction of thermostats. Consider installation of ammeters in heater supply circuits to monitor full load current of heaters on each circuit to ensure that all are operating.
	Cable terminations (8-1 through 8-4).	Observe stress cones and leakage sections annually for cleanliness and tracking.
	Adequate grounding (6-1.5) (6-8.9).	
	Also observe conditions:	
	Loading.	Record loads if gear is equipped with ammeters.
	Cleanliness (6-2.9).	Moderate amount of dry nonconductive dust not harmful.
	Dryness (6-2.6).	Evidence of condensation or water leaks.
	Rodents and reptiles.	
	Overheating of parts (6-2.14).	Discoloration and/or oxidation indicate possible problem. Infrared survey may be beneficial. Use good quality infrared scanning equipment. Switches should be loaded to at least 30 percent of rating while being scanned.
	Tracking on insulating surfaces (6-2.13).	Make necessary repairs.
	Major Maintenance or Overhaul:	Three to six years, depending upon ambient conditions.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Completely clean, inspect, tighten and adjust all components (6-4.1):	Follow manufacturer's maintenance instructions.
	Structure and enclosure (6-2.3 & 6-2.4).	Wire brush and prime paint rust spots. Finish paint.
	Ventilating louvers and air filters (6-2.8).	Clean or replace air filters as required.
	Buses, splices and bolts (6-1.3) (6-2.14).	Check bolts for manufacturer's recommended torque.
	Insulators and insulating materials (6-1.2) (6-2.10 through 6-2.14).	Clean and inspect for surface tracking.
	Space heaters (6-2.7).	Operate continuously to overcome possible malfunction of thermostats. Consider installation of ammeters in heater supply circuits to monitor full load current of heaters on each circuit to ensure that all are operating. These ammeters will permit frequent check of heater operation while switches are energized.
	Main switch blades and contacts (6-4.1) (6-2.14) (6-4.3).	Use safety precautions if switch is stored energy type. Lubricate.
	Arcing switch blades and contacts (6-4.3.2).	Dress or replace if arc eroded. Do not lubricate.
	Arc chutes or interrupter devices (6-4.4).	Check for condition, alignment and proper operation.
	Switch operating mechanism and linkage (6-4.5).	Adjust for adequate contact closure and overtravel. Lubricate.
	Switch/fuse door and other interlocks (6-8.8).	Make functional check for proper operation sequence.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 6-Metal Enclosed Switches (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor Air (Cont.)	**Major Maintenance or Overhaul (Cont.):**	
	Switch disconnect studs and finger clusters (if switch is draw-out type) (6-4.3.7).	Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Cable terminations and connections (8-1 through 8-4).	Clean and inspect for surface tracking. Check connections for tightness.
	Meters (6-8.7).	Check for accuracy.
	Fuse clips and fuses (13-2).	Check clips for adequate spring pressure. Proper fuse rating.
	Grounding (6-1.5) (6-8.9).	
	Potential and control power transformers (6-8.5).	
	Current transformers (6-8.5).	
	Auxiliary devices (6-4.6).	
	Components and conditions in above blocks.	Make necessary repairs.
	Testing (Chapter 18) (5-3):	Three to six years, depending upon ambient conditions.
	Test buses, breakers, PT's, CT's and cables with high potential DC.	Record leakage currents in microamperes (18-9.2.4) (8-5).
	Calibrate and test protective relays (18-10.3).	Refer to Protective Relays section.
	Functionally open electrically operated type switches with protective relays (18-10.3.2.7).	
	Test conductivity of switch contacts and aluminum cable connections.	Use microhmmeter or determine voltage drop under test load conditions (18-12).
	Test wiring for controls, meters and protective relays for insulation resistance (18-9.2.1).	1000 volt megohmmeter for control wiring. 500 volt megohmmeter for meters and relays.
Outdoor Air	**Inspections (while energized):**	One to three months.
	Same as for indoor gear except:	
	Special emphasis on evidence of condensation and water leaks (6-2.3) (6-2.5) (6-2.6).	Rust spots on underside of metal roof indicative of condensate.
	Special emphasis on space heater operation (6-2.7).	
	Ventilating louvers and air filters for cleanliness (6-2.8).	Clean or replace air filters as required.
	Major Maintenance or Overhaul:	Three years. More often if conditions require.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Same as for indoor gear (6-4.1).	
	Testing (Chapter 18) (5-3):	Three years. More often if conditions require.
	Same as for indoor gear.	
Oil and Gas	**Exterior Inspection:**	Annually.
	Check oil level and gas pressure in switch.	
	Take oil or gas sample.	Test as recommended by manufacturer.
	Check for evidence of leakage.	Repair if necessary.
	Inspect exterior of switch for corrosion.	Paint as required.
	Major Maintenance or Overhaul:	After 500 operations.
	De-energize (5-3) (6-4.1). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Drain or vent insulating medium.	
	Check gaskets for cracks and flexibility.	Replace where necessary.
	Check cable entrances for mechanical damage or tracking.	

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 6-Metal Enclosed Switches (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Oil and Gas (Cont.)	**Major Maintenance or Overhaul (cont.):**	
	Inspect all mechanical and electrical connections for tightness.	
	Clean switch interior.	
	Refill.	Use new or reconditioned oil or gas.
	Testing:	
	Actuate each operating mechanism.	Check for proper operation.
	Test with DC high potential tester.	

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 7-Buses and Bus Ducts.

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor	**Inspections (while energized):**	Three to six months.
	Open buses:	
	Condition of bus conductors (6-1.3).	
	Evidence of overheated joints (6-1.3) (6-2.14).	Discoloration and/or oxidation indicate possible problem. Infrared survey may be beneficial. Use good quality infrared scanning equipment. Buses should be loaded to at least 30 percent of capacity while being scanned.
	Condition of insulators and insulated sleeving (6-1.2).	Cleanliness and breaks.
	Clearance from grounded metal surfaces and above floor.	
	Guards and caution signs.	Where required.
	Loading.	Make certain load is within ampacity rating.
	Bus duct (covers in place):	
	Condition of enclosures(6-2.3).	
	Evidence of water drips on enclosure.	Investigate and correct immediately.
	Adequate grounding (6-1.5) (6-8.9).	
	Loading.	Make certain load is within ampacity rating.
	Maintenance and Tests (de-energized):	One to six years, depending on conditions.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Open buses:	
	Check for evidence of overheated joints (6-1.3) (6-2.14).	Discoloration and/or oxidation of bare joints indicate possible problem. Charred tape or cover over insulated joint indicates problem.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 7-Buses and Bus Ducts (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor (Cont.)	**Maintenance and Tests (de-energized) (cont.):**	
	Check connection bolts for tightness where not covered (6-1.3).	Torque according to manufacturer's installation instructions.
	Clean and inspect insulators (6-1.2).	For cracks, chips, breaks and surface tracking.
	Clean and inspect insulated sleeving over buses, if provided.	For cracks, breaks, properly taped joints and surface tracking.
	DC high-potential test (18-9).	Record results.
	Bus duct (covers removed):	
	Clean and check condition of sleeving over buses (6-2.1.3) (6-2.10 through 6-2.13).	For cracks, breaks, properly insulated joints and surface tracking. Make necessary repairs.
	Clean and inspect insulators (6-1.2).	For cracks, chips, breaks and surface tracking or burning.
	Check for evidence of internal moisture (6-2.6).	From water leaks or condensation.
	Check for proper ventilation (6-2.8).	All ventilating louvers should be open.
	Check for proper space heater operation (6-2.7).	Operate continuously to overcome possible malfunction of thermostats. Consider installation of ammeters in heater supply circuits to monitor full load current of heaters on each circuit to ensure that all are operating. These ammeters will permit frequent check of heater operation while buses are energized.
	Check space heater wiring.	For proper clearances from buses.
	Check condition of enclosure (6-2.3).	Close all unused holes.
	Check grounding connections (6-1.5).	For tightness.
	Check integrity of barriers.	
	DC high-potential test (18-9).	Record results.
Outdoor	**Inspections (while energized):**	Three to six months.
	Open buses:	
	Same as for indoor buses.	
	Bus duct (covers in place):	
	Condition of enclosure (6-2.3).	Enclosure should be weatherproof type.
	Adequate grounding (6-1.5) (6-8.9).	
	Loading.	Make certain load is within ampacity rating.
	Maintenance and Tests (de-energized):	Three to six years.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Open buses:	
	Same as for indoor buses.	
	Bus duct (covers removed):	
	Same as for indoor bus duct plus following:	
	Check condition of cover gaskets (6-2.5 & 6-2.6).	For deterioration, breaks and omissions.
	Check operation of space heaters (6-2.7).	Operate continuously to overcome the possible malfunction of thermostats. Consider installation of ammeters in heater supply circuits to monitor full load current of heaters on each circuit to ensure that all are operating. These ammeters will permit frequent check of heater operation while buses are energized.
	Check enclosure ventilating louvers (6-2.8).	For cleanliness of air filters. Clean or replace. For ability to exclude insects, rodents, reptiles and metal rods.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 8- Protective Relays

Equipment	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Induction Disk Relays (Draw-out Type) (18-10.3)	**Inspection, Cleaning, Maintenance, Calibration and Testing (while associated circuit breaker is closed and supplying load):**	Three years. More often where dust, moisture, corrosion, vibration or wide temperature variations are present. Follow manufacturer's instructions for type of relay and test set.
	Brush or blow dust off top edge of relay cover and remove cover.	Use caution to not accidentally cause relay contacts to close, which would trip associated circuit breaker and shut down load.
	Remove relay disconnect device or open relay trip circuit switch and then open supply circuit switches in relay case.	Remove only one relay from service at a time. Leave other relays in service to provide protection for circuit.
	Release locking mechanisms, withdraw relay from case, and place on workbench in clean area adjacent to test equipment.	Handle with care to avoid damage to delicate mechanism.
	Clean mechanism with soft, long bristle brush and/or very light air pressure from hose.	
	Tighten all screws and nuts. Inspect for broken or defective connections.	Do not overtighten. Repair defective connections.
	Inspect closely for dust and iron filings clinging to magnet and in air gap which might restrict rotation of disk.	Thoroughly clean to remove dust and foreign matter.
	Inspect for correct alignment of disk and proper clearances from mechanism, magnet, etc.	Make necessary adjustments to provide proper clearances so disk does not drag on mechanism or magnet.
	Burnish contact surfaces and inspect contacts for burning and pitting.	Use relay contact burnishing tool. Replace contacts if badly burned or pitted.
	Inspect disk restraint spring.	For proper shape, tension, and possible damage from overheating due to excessive current, flow through same.
	Record as-found time lever setting and temporarily set time lever adjustment on position 10. Turn disk with thumb until relay contacts close.	Check to detect if disk binds at any point. Examine spring and contacts in closed position. Make necessary adjustments, repairs or replacements.
	Release disk and allow it to reset until contact bracket is resting against "full-open" stop device.	Watch disk movement to detect if disk slows down or stops before contact bracket rests against the "full-open" stop device. If so, make necessary adjustments, repairs or replacement.
	Reset time lever to "as-found" position or to the desired new position, if different one is specified on the applicable coordination or instruction sheet.	Refer to applicable time/current coordination sheet or setting instructions which are necessary to obtain correct coordination with associated upstream and/or down stream protective devices.
	Check current tap plug for correct position and tightness. Reposition, if necessary, to agree with setting specified on applicable coordination sheet.	Ditto above item.
	If precise relay operation accuracy is required, it might be necessary to test some types of relays in their own cases in switchgear or in an unwired duplicate case located on workbench.	For "in case" testing, connect relay test set leads to proper type relay test jack and insert it into relay disconnect contacts, being careful to make connections in accordance with applicable instructions and diagrams. If relay is in its own case, make certain that it is disconnected from the switchgear wiring to the relay case by means of open switches in the case or by wiring to only the relay side of the test jack. Make certain that switchgear side of test has jumpers installed to short out all CT circuits.
	Some relays may be satisfactorily tested outside of case.	Place withdrawn relay on a clean workbench and connect test leads to proper terminals using alligator clips.
	Select test points from applicable coordination or instruction sheet and calculate amount of current or voltage to be applied to relay operating coil. Adjust test set to apply proper values of test current and/or voltage.	Consider switchgear PT and/or CT ratios in calculating proper amount of test current or voltage. Pass test current through current coils. Apply test voltage across potential coils.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 8- Protective Relays (Continued)

Equipment	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Induction Disk Relays (Draw-Out Type) (Cont.)	**Inspection, Cleaning, Maintenance, Calibration and Testing (while associated circuit breaker is closed and supplying load) (Cont.):**	
	Test relay pickup point by applying test set voltage or current (determined from coordination curve) at which disk begins to turn very slowly.	After disk begins to turn slowly, lower test current or voltage slightly and check if disk stops turning and resets. Make necessary adjustments or repairs. Record results.
	Connect desired relay contact to timer circuit of test set. Adjust test set for current and/or voltage specified to test time contacts of relay. Push "initiate" button on test set and check actual time required for relay time contacts to close.	When contacts close, test set will automatically remove applied test current and/or voltage, and its accurate timer will stop.
	Compare actual time with time specified on coordination curve.	If actual time is close enough to the specified time to satisfy the required coordination accuracy, record results and proceed to next step. If not, readjust time lever accordingly and repeat test. Continue until the desired timing accuracy is attained.
	If relay is equipped with instantaneous current attachment, adjust test set for current and/or voltage specified for testing same on coordination sheet. Apply and check accurate timer for time required for instantaneous contacts to close. Adjust instantaneous setting to close contacts at current value specified on coordination sheet.	After desired results are obtained, reduce test current slightly and check that relay contacts do not close at value below that specified. If they do, further adjustment and retesting at the specified current will be required until the close and no-close results are within the allowed tolerances.
	Test seal-in contacts for closing at specified values.	
	Check target flags for proper operation each time relay contacts close. Leave all targets in "dropped" position.	Reset target flags and check that moderate vibration does not cause a false operation.
	Record "as-found" and "as-left" settings; test current values and operating results; and maintenance and corrective action taken.	
	Clean and inspect interior of relay case located in switchgear.	Use soft bristle brush and/or stream of low pressure dry and clean air, being careful to not open current shorting contacts or short potential contacts. Do not short trip circuit terminals, etc.
	Clean glass or plastic window in relay cover and check target reset mechanism for free movement.	Use cleaning materials that will not damage plastic.
	Insert relay into its case in switchgear and secure locking devices. Insert connection device or close switches inside relay case.	Observe that disk does not begin to rotate. If it does, remove connection device before contacts close and trip breaker; investigate reason; and make necessary correction. On relays with individual switches, close current and/or potential switches and observe that disk does not rotate before closing trip circuit switch.
	Replace relay cover and secure fastenings. Operate target reset mechanism to determine that targets reset properly.	
	Seal relay cover to discourage unauthorized entry.	

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 8- Protective Relays (Continued)

Equipment	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Induction Disk Relays (Nondraw-out Type) (18-10.3)	**Inspection, Cleaning, Maintenance, Calibration and Testing:** Same general procedures as for draw-out type, except relays cannot be easily removed from their cases and switchgear. A test receptacle is usually provided in the switchgear adjacent to each relay to facilitate testing. A suitable isolating test jack is connected to the relay test set and inserted into the test receptacle. This disconnects the relay contacts from the breaker trip circuit in the switchgear and connects the test set current and/or potential leads to the proper operating coils in the relay.	Same frequency and remarks as for draw-out type relays. Make certain that the connections to the test jack are correct before inserting test jack into test receptacle.
All Types (18-10.3)	**General Maintenance and Functional Testing (switchgear de-energized and associated breakers out of service)** (5-3):	Three to six years to coincide with major switchgear maintenance.
	Same as above, except checking condition of wiring and terminals.	Check wiring for condition of conductors and insulation. Check terminals for tightness.
	Functionally test by closing associated circuit breaker and injecting proper value of test current into associated CT circuit and/or applying proper value of test voltage to associated potential wiring after disconnecting same from its supply PT's.	Check to determine that contacts of proper relays close and that associated breaker trips open. If not, determine cause and make necessary corrections.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 9-Automatic Transfer Control Equipment

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor and Outdoor	**Inspections (while energized) of:**	Three to six months.
	Protective, sensing, timing and control relays.	For condition of contacts.
	Control wiring and terminals.	General condition.
	Control power batteries (6-8.4).	
	Enclosure (6-2.3) (6-2.5 & 6-2.6) (6-2.8 & 6-2.9).	Cleanliness and evidence of condensation and leaks.
	Space heaters (outdoor enclosures) (6-2.7).	Operate continuously to overcome possible malfunction of thermostats. Consider installation of ammeter in heater supply circuit for frequent monitoring of full load current of heaters to ensure that all are operating. These ammeters will permit frequent check of heater operation while buses are energized.
	Maintenance and Testing (while de-energized) (5-3):	Three years. More often if conditions require.
	Clean enclosure, relays, control devices, etc. (6-8.7).	
	Clean, inspect and burnish contacts.	
	Test and calibrate protective relays (18-10.3).	Refer to Protective Relays section.
	Tighten terminals.	
	Test circuits and devices insulation.	Use 500 volt DC insulation resistance tester.
	Maintain enclosure.	Wire brush and prime rust spots. Finish paint.
	Functionally test by placing selector switch in manual position and operating control switches to open and close associated circuit breakers.	Remove breakers from service.
	Functionally test by placing selector switch in automatic position and simulating conditions that should cause controls to operate associated breakers to effect transfer of power.	Remove breakers from service.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 10-Fuses

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
All Types (Chapter 13)	**Visual Inspection (while energized) for:**	Three to six months. Binoculars may be necessary to inspect fuses on overhead lines.
	Evidence of contact overheating.	Discoloration and/or oxidation indicate possible problem. Infrared survey may be beneficial. Use good quality infrared scanning equipment. Fuses should be loaded to at least 30 percent of rating while being scanned.
	Cracked, chipped or broken insulation of fuse barrels and mounting insulators (6-1.2) (13-2.3.1).	
	Cleanliness of insulation surfaces.	
	Overload.	Steady load should not exceed E rating of fuse.
	Proper oil level in barrel of oil-filled type.	
	Maintenance (while de-energized) (13-2.2) (5-3):	Three to six years, depending on ambient conditions.
	Remove fuses from mountings and inspect for:	
	Cleanliness (13-2.3.1) (6-1.2).	Clean insulating and contact surfaces.
	Cracked, chipped or broken insulation (13-2.3.1).	Replace defective insulation.
	Evidence of overheating and arc erosion on fuse ferrules and spring clips on mountings (13-2.3.2).	Replace defective parts.
	Tension of spring clips and pressure against contact surfaces (13-2.3.3).	Replace weakened or annealed spring clips.
	Tightness of connections (13-2.3.3).	
	Ampere rating agreement with specified rating (13-1.3).	Disassemble refill-type fuses and check nameplate information on refill unit.
		Check contact surfaces for evidence of overheating.
		Reassemble and tighten securely.
	Interrupting rating adequacy for fault capability of system on which fuse is installed (13-1.3).	
	Testing (while de-energized) (5-):	Three to six years.
	Mounting insulators may be DC high-potential tested (18-9.2.4).	High-potential testing of fuse mountings is not a standard maintenance practice.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-2 Medium Voltage Equipment, 11-Lightning Arresters

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
All Types	**Visual Inspection (while energized) for:**	Three to six months. Binoculars may be necessary to inspect arresters on overhead lines.
	Cleanliness of porcelain surfaces (6-8.2.1).	
	Cracked, chipped or broken porcelain (6-1.2).	
	Disconnected line or ground connections.	
	Maintenance (while de-energized) (5-3):	Three to six years, depending on ambient conditions.
	Clean porcelain surfaces (6-8.2.1).	Consider application of silicone grease in badly contaminated areas. Should be removed and reapplied at max. two-year intervals; preferably one year.
		Wire-brush and prime paint rust spots. Finish paint.
	Check tightness of line and ground connections.	
	Inspect nameplate data for voltage rating suitability for system voltage and grounding.	
	Clean internal porcelain surfaces of nonsealed arresters if test results indicate contamination present.	
	Testing (while de-energized) (5-3):	Three to six years.
	Power factor test (6-8.2.2).	Record results.
	Test insulation resistance (6-8.2.2).	Record results.
		Compare resistances of all arresters of same rating and type, which should be approximately the same.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-3 Medium and Low Voltage Equipment, 1-Outside Overhead Electric Lines

Equipment	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Wood Poles	**Inspect from Ground Level for Following:**	Four to six months.
	Leaning.	Binoculars usually required.
	Washout.	
	Splitting.	
	Bird damage.	
	Lightning damage.	
Wood Crossarms	Twisting.	Four to six months.
	Splitting.	Binoculars usually required.
	Decay.	
	Loose or missing braces.	
	Loose pins.	
	Surface tracking or burning (6-2.13).	
Insulators and Bushings	Cracks (require careful inspection) (6-1.2.1).	Four to six months.
	Chips or bad breaks (6-1.2.1).	Binoculars usually required.
	Unscrewed from pin.	
	Leaning at bad angle.	
	Cleanliness (6-1.2.1).	If atmosphere is contaminated, annual or biannual cleaning and coating of porcelain insulator surfaces with silicone grease might be necessary. This can be done with lines energized by using special equipment, materials and trained personnel.
Lightning Arresters	Cracked, chipped and broken insulators (6-1.2.1) (6-8.2.1).	Four to six months.
	Ground connection (6-1.5) (6-8.9).	Binoculars usually required.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-3 Medium and Low Voltage Equipment, 1-Outside Overhead Electric Lines (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Lightning Arresters (Cont.)	**Inspect from Ground Level for Following (Cont.):**	
	Cleanliness.	If atmosphere is contaminated, annual or bi-annual cleaning and coating of porcelain insulator surfaces with silicone grease might be necessary. This can be done with lines energized by using special equipment, materials and trained personnel.
Guys and Anchors	Broken strands. Corrosion. Looseness and slippage. Loose clamps. Excessive tension. Anchor eye above ground. Adequate clearance from conductors. Insulators properly located.	Four to six months. Binoculars usually required.
Conductors	Off insulator and resting on crossarms. Broken strands. Blisters or burned spots. Excessive or uneven sagging. Loose connections (6-2.14) (6-1.3) (18-15). Horizontal and vertical clearances. Trees that touch or can fall across conductors.	Four to six months. Binoculars usually required.
Hardware	Looseness. Corrosion.	Four to six months. Binoculars usually required.
Switches and Fuses	General condition. Broken arcing horns. Bent or misaligned arms.	Four to six months. Binoculars usually required.
Connections	Evidence of overheating (6-2.14) (6-1.3) (18-15).	Four to six months. Binoculars usually required. Infrared survey can be beneficial.
Ground Wires	Breaks (6-1.5). Attachment to pole.	Report on all conditions that require correction. Make necessary repairs.
All Poles	**Climbing or Bucket Truck Inspection for Detailed Inspection of Foregoing Items and Conditions:**	Three to five years. Tighten hardware and make necessary repairs and replacements. Wire-brush, prime and finish-paint rusted areas of metal poles.
Wood Poles and Crossarms	**Ground-line Inspection and Preservative Treatment:** Sound pole with hammer to 6 ft above ground. Excavate to 18 inches–20 inches below ground, wirebrush, inspect for surface decay. Test bore to determine internal decay — if found, determine extent. Apply preservative to external surface from 20 inches below grade to 6 inches above. Wrap treated area with protective film and backfill excavation.	Eight to ten years in southern areas. Ten to fifteen years in northern areas. Cut out moderate decay pockets. If not too extensive, inject preservative fluid and plug holes. If decay is excessive, reinforce or replace pole.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-3 Medium and Low Voltage Equipment, 1-Outside Overhead Electric Lines (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Wood Poles and Crossarms (Cont.)	**Above-ground Inspection and Preservative Treatment as Follows:**	
	Sound pole with hammer. Bore hollow areas and inject preservative fluid — plug holes.	
	Bore pole 6 inches above bolts and inject preservative fluid — plug holes.	
	Inspect crossarms for decay pockets.	
	Apply preservative treatment.	Replace crossarm if decay is extensive.
	Inspect roof for decay. Apply preservative and cover.	If decay is present but does not extend below top crossarm, cut off pole to sound wood, treat with preservative and install cover.
	Inspect all wood for termites.	Treat if not excessive.
	Tighten pole hardware.	
	Inspect for bird (woodpecker) damage.	Fill holes with compound if pole is not excessively weakened by damage. Weakened areas may be reinforced.
Current-carrying Parts	**Thermal Scanning or Infrared Inspection** (18-15):	Five to eight years.
	Scan all conductors, connectors, switches, fuses, etc., with special thermal detecting equipment to locate hot spots caused by loose connectors and bad contacts.	Conductors should be loaded to approximately one-third ampacity for effective results.
		Use good quality infrared scanning equipment.
		Small gun-type thermal detectors not usually effective at overhead line distances and require too much time.
		Make repairs or replacements as indicated by results.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 1-Low Voltage Cables and Connections

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Solid Dielectric, Elastomeric, PVC, etc. (Chapter 8)	**Inspections (while energized) of** (8-2.1):	One year.
	Conduit entrances (8-4).	Observe for deformation due to pressure and for bends with radius less than minimum allowed.
	Poles and supports.	Ditto.
	Binder tape terminations (aerial cables) (8-3).	Ditto.
	Ends of trays (8-4).	Ditto.
	Splices (8-2.3).	Ditto.
	Terminal lugs and connectors (8-2.3) (8-2.5).	Observe for evidence of overheating. Infrared survey may be beneficial. Use good quality infrared scanning equipment. Conductors should be loaded to at least 30 percent capacity while being scanned.
		Discoloration and/or oxidation indicate possible problem.
	Fireproofing (where required) (8-2.3).	Observe for continuity.
	Loading.	Make certain loads are within cable ampacity rating.
Varnished Cambric Lead Covered	**Inspections (while energized) of** (8-2.1):	
	Same as above.	Same as above.
	Lead sheath (8-2.3).	Observe for cracks or cold wipe joints — often indicated by leakage of cable oil or compound.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 1-Low Voltage Cables and Connections (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
All Types	**Major Maintenance and Testing (de-energized):**	Three to six years.
	De-energize (5-3) (8-2.1). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Complete inspection same as above blocks.	Same as above blocks.
	Clean porcelain of potheads (8-2.5) (6-1.2.1).	Inspect for cracks and chips.
	Check general condition of cable.	Does insulating material appear to have been damaged by overheating?
	Observe lugs and connectors for overheating (8-2.5) (6-1.3) (6-2.14).	Discoloration and/or oxidation indicate possible problem. Check bolts for tightness.
	Test cable insulation with high potential DC (8-5) (18-9.1 & 18-9.2) (18-9.2.4).	Disconnect cables from equipment. Record leakage current in microamperes at each test voltage level. Record temperature and relative humidity.
	As an alternate, test cable insulation resistance (18-9.2.1).	Use 2500 volt or 5000 volt megohmmeter.
	Determine condition of cable insulation (18-9.2.4.3).	Interpret test results, considering length of cable, number of taps, temperature and relative humidity.
	Reconnect cables to equipment.	Tighten connectors adequately.
	Aluminum conductors.	Make certain that connectors are of the proper type and correctly installed. Use Belleville washers when bolting aluminum cable lugs to equipment. Advisable to determine conductivity of connection using microhmmeter or determine voltage drop under test load conditions (18-12).

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 2-Dry-Type Transformers

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Ventilated and Nonventilated	**Inspections (while energized) of:**	Monthly.
	Operating temperature (7-3.4).	Odor of overheated insulation in vicinity of ventilated transformer may be best indication of problem. 150°C is max. operating temperature for transformers rated 80°C rise. 220°C is max. operating temperature for transformers rated 150°C rise. Nonventilated enclosure of latter may normally be too hot to touch.
	Cleanliness of ventilation louvers in enclosure and excessive accumulation of dust on top of nonventilated enclosure (7-3.6).	Clogged louvers restrict ventilation and thereby increase operating temperature of core and coil assembly. Vacuum louvers without de-energizing transformer if dust and lint are on outside. If dust and lint are inside, transformer must be de-energized and enclosure sides removed to clean louvers, etc. Clean excessive accumulation of dust off top of nonventilated enclosure.
	Area ventilation and temperature (7-3.6).	If ambient temperature exceeds maximum allowed, transformer should be derated accordingly.
	Loading.	Make certain loading is within rating of transformer.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 2-Dry Type Transformers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Ventilated and Nonventilated (Cont.)	**Major Maintenance (de-energized):**	Three to six years. More often if required.
	De-energize (5-3) (7-3.7). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Remove enclosure covers and clean vent louvers (7-3.7.2).	
	Clean insulators, core and windings (7-3.7.2 & 7-3.7.3).	Use bottle of dry air or nitrogen with pressure regulator, hose and small nozzle to blow off dust. Restrict pressure to 30 psi max. Clean with soft bristle brush as required.
	Inspect following components:	
	Wedges and clamping rings (7-3.7.2).	For proper clamping of windings. Tighten as required.
	Primary and secondary buses and conductors (7-3.7.2) (6-1.3).	For tightness of connections and evidence excessive heat.
	Porcelain insulators (6-1.2).	For chips, cracks and water streaks.
	Insulating materials (7-3.7.2) (6-2.10 & 6-2.14).	For breaks and damage due to excessive heat.
	Windings (7-3.7.2) (6-2.14) (7-3.7.3).	For damage to insulation, including overheating.
	Tap connections (7-3.7.2).	For tightness and correctness to provide proper voltage.
	Core assembly.	For loose and/or dislocated laminations, localized or general overheating and for integrity of ground strap which is *only* place where core assembly is permitted to be grounded.
	Ventilating channels between core and windings and between windings (7-3.7.3).	For clogging with lint, dust or tape used to hold spacers, etc., in place during assembly. Clean as required to allow proper air flow.
	Testing (de-energized):	Three to six years. More often if required.
	De-energize (5-3) (7-3.7). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Polarization index test (7-2.9.1) (7-2.9.2 & 7-2.9.3).	Use 1000 volt megohmmeter. Low P.I. results often indicate moisture in winding. If so, investigate cause and satisfactorily dry transformer before making high potential DC test and returning transformer to service.
	High potential DC test (7-2.9.4) (18-9.2.4).	Record leakage currents in microamperes, temperature and relative humidity.
	As an alternate, test transformer with 1000 volt, 2500 volt or 5000 volt megohmmeter (7-2.9.1.1).	Use 1000, 2500 or 5000 volts DC depending on size and voltage rating of transformer.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 3-Switchgear

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor (Chapter 6)	**Inspections (while energized):**	Three to six months.
	Open doors and inspect components:	
	Fronts of circuit breakers.	Detect overheating.
	Protective and control relays (if used) (6-8.7).	Control wiring — not internals.
	Auxiliary devices, wiring and terminal blocks (6-4.6).	Proper indicating lamps should light.
	Insulators and insulating materials (6-1.2) (6-2.10 through 6-2.14).	
	Cable connections (6-2.14).	Observe for evidence of overheating. Infrared survey may be beneficial. Use good quality infrared scanning equipment. Conductors should be loaded to at least 30 percent of capacity while being scanned.
	Batteries (if used) (6-8.4).	
	Also inspect for following conditions:	
	Loading.	Record loads. Make certain loads are within ampacity ratings of breakers and their overcurrent trip coils.
	Cleanliness (6-2.9).	Moderate amount of dry nonconductive dust not harmful.
	Dryness (6-2.5 & 6-2.6).	Evidence of condensation or water leaks.
	Rodents and reptiles (6-2.4).	
	Overheating of parts (6-2.14).	Discoloration and/or oxidation indicate possible problem. Infrared survey may be beneficial. Use good quality infrared scanning equipment. Components should be loaded to at least 30 percent of capacity while being scanned.
		Make necessary repairs.
	Major Maintenance or Overhaul:	Three to six years, depending on ambient conditions.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Completely clean, inspect, tighten and adjust all components (6-4.1):	Follow manufacturer's instructions.
	Structure and enclosure (6-2.3 & 6-2.4).	Wire-brush and prime paint rust spots. Finish paint.
	Ventilating louvers (6-2.8).	Clean.
	Buses, splices and bolts (6-1.3) (6-2.14).	Check bolts for manufacturer's recommended torque.
	Insulators and insulating materials (6-2.10 through 6-2.14) (6-1.2).	Clean and inspect for cracks.
	Circuit breakers (6-4) (6-5) (6-6).	Refer to Circuit Breaker section.
	Breaker disconnect studs (6-4.3.7).	Inspect for pitting and evidence of overheating. Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Breaker disconnect finger clusters (6-4.3.7).	Inspect for proper adjustment and spring pressure and overheating. Inspect retainer rings for stress cracks in corners: Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Cable connections (8-1 through 8-4) (6-1.3) (6-2.14).	Inspect for evidence of overheating. Check for tightness. Use Belleville washers on aluminum lugs.
	Draw-out breaker racking mechanisms (6-1.7).	Alignment and ease of operation.
	Meters (6-8.7).	Test for accuracy.
	Controls, interlocks and closing power rectifiers (6-8.8).	Make functional tests.
	CT's, PT's and control power transformers (6-8.5).	Check voltages.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 3-Switchgear (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor (Cont.)	**Major Maintenance or Overhaul (Cont.):**	
	Fuse clips and fuses (13-2).	Check clips for adequate spring pressure. Proper fuse rating.
	Grounding (6-1.5) (6-8.9). Components and conditions in above block.	Make necessary repairs.
	Testing (de-energized) (Chapter 18):	Three to six years, depending on ambient conditions.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Test buses, breakers, PT's, CT's, wiring and cables for insulation resistance (18-9.2.1).	2500 volt DC on buses, breakers and 600 volt equipment. 1000 volt DC on control wiring. 500 volt DC on meters and protective relays.
	Calibrate and test protective relays (18-10.3).	Refer to Protective Relays section.
	Functionally trip breakers with relays (18-10.3.2.7).	Preferably, inject test current into CT and relay circuits.
	Calibrate and test overcurrent trip devices (6-4.6.4) (6-4.6.5) (18-10).	Use high current test equipment and adjust trips to operate in accordance with manufacturer's and specially prepared time-current coordination curves. Adjust for proper conformance.
	Test conductivity of aluminum cable connections (18-12) (6-1.3).	Use microhmmeter or determine voltage drop under test load conditions. Use Belleville washers when bolting aluminum cable lugs to equipment.
Outdoor (Chapter 6)	**Inspections (while energized):**	One to three months.
	Same as for indoor gear plus:	
	Space heaters (6-2.7).	Operate during cool weather.
	Special emphasis on condensation and water leaks (6-2.3) (6-2.5) (6-2.6).	Rust spots on underside of roof indicative of condensation.
	Air filters behind ventilating louvers (6-2.8).	Clean or replace as required.
	Major Maintenance or Overhaul:	Three years. More often if conditions require.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Same as for indoor gear (6-4.1).	Follow manufacturer's maintenance instructions.
	Testing (de-energized) (Chapter 18):	Three years. More often if conditions require.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.** Same as for indoor gear.	

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 4-Draw-Out Type Circuit Breakers

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Air-break (6-4)	**Inspection and Maintenance (withdrawn from switchgear and de-energized):**	Maximum of three years or at manufacturer's maximum number of operations since previous maintenance, whichever occurs first. Immediately after breaker opens to interrupt a serious fault. Follow manufacturer's maintenance instructions. If breaker is stored energy closing type, follow manufacturer's safety precautions, determine that closing springs are discharged or mechanism is blocked to prevent personal injury. Keep hands away from contacts and mechanism while test operating breaker (6-4.1.1).
	Remove arc chutes. Inspect, adjust and clean where necessary:	
	Main contacts (6-4.3).	For pitting, spring pressure, overheating, alignment, overtravel or wipe. Adjust or replace accordingly.
	Arcing contacts (6-4.3.2).	For alignment, overtravel or wipe and for arc erosion. Adjust or replace accordingly.
	Moving parts and linkages (6-4.5.1 through 6-4.5.3).	For freedom of movement.
	Closing mechanism (6-4.5).	For quick and positive closing action.
	Tripping mechanism (6-4.5).	For freedom of movement and reliability to open breaker contacts.
	Interlocks and safety devices (6-8.8) (6-4.6.2).	Functionally test to prove proper operation.
	Primary disconnect finger clusters (6-4.3.7).	For proper adjustment and spring pressure. Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Secondary disconnect contacts (6-4.3.7).	For alignment and spring pressure. Lubricate.
	Closing and trip coils (6-4.6.1).	General condition and evidence of overheating.
	Spring charging motor and mechanism (stored energy type) (6-4.6.1).	Proper operation. Oil leaks from gear motor.
	Shunt trip device (6-4.6.1).	For freedom of movement. Functionally test.
	Undervoltage trip device.	For freedom of movement. Functionally test.
	Anti single-phase or blown fuse lockout devices (fused breakers only).	General condition. Functional test with proper voltage to trip and lock-out breaker.
	Auxiliary contacts.	For proper operation with closing and opening of breaker.
	Closing (x and y) relays (electrically operated breakers).	Contact erosion. Dress or replace as required.
	Current transformers (6-8.7.2) (6-2.10).	General condition. Check nameplate ratio.
	Connection bolts (9-3.1).	Check for tightness.
	Structure or frame (9-3.1; 9-3.2 & 9-3.3).	For proper alignment and loose or broken parts.
	Fuses and mountings (13-1).	General condition and tightness.
	Frame grounding device.	Connect before and disconnect after primary fingers.
	Position indicators (6-4.6.2) (6-8.6.2).	For proper operation.
	Auxiliary wiring (6-4.4).	General condition and tightness of terminal screws.
	Arc chutes.	For broken parts, missing arc splitters and amount of metal spatter and burning on interior surfaces. Snuffer screens must be clean. Repair or replace as necessary.
	Operation counter (if so equipped).	For proper operation. Record number of operations.
	Insulators and insulating materials (6-2.10). (6-2.14).	For cracks, breaks and overheating.
	Breaker auxiliary devices (6-4.6).	Make necessary repairs.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 4-Draw-Out Type Circuit Breakers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Air-break (Cont.)	**Testing (withdrawn from switchgear and de-energized)** (5-3) (18-5; -6; -7 and -8): Test insulation resistance (18-9.1 & 18-9.2) (18-9.2.1) (18-9.2.2).	Maximum of three years, etc., same as above block. 2500 volt meghommeter on each main contact with breaker open and all other main contacts and frame grounded. 1000 volt meghommeter on auxiliary devices and controls and associated wiring, except solid state trip devices.
	Contact conductivity or resistance (15-12).	Use microhmmeter or determine voltage drop under test load conditions.
	Overcurrent trip devices (electromechanical, series type) (18-10.2.9) (6-4.6.4).	Pass specified currents from high current test set through coils of series type O.C. trip devices. Trip devices should open breaker contacts within time limits according to manufacturer's or specially designed time-current coordination curves. Adjust trip devices as required to accomplish desired results. Test set should be equipped with cycle counter for accuracy of short-time and instantaneous trip tests. Record results.
	Overcurrent trip devices (electromechanical, 5 amp CT type) (18-10.2.9).	Test 5-amp, type O.C. trip devices in similar manner using reduced current proportional to ratio of CT's in switchgear that normally supply current to the O.C. trip coils. Record results.
	Overcurrent trip devices (solid state type) (18-10.2.8) (6-4.6.5).	Use manufacturer's instructions and test set specifically designed for solid state trip device being tested, or use primary injection from high current test set. Adjust trip device settings to obtain desired tripping times and currents to conform with applicable coordination curves. Record results. Do not use megohmmeter insulation resistance tester on solid state trip devices or associated wiring.
	System Testing (breaker installed): Electrically operated breaker.	After above maintenance and testing has been satisfactorily completed, install electrically operated breaker in proper switchgear cell and rack it into "TEST" position. Operate closing control devices to assure that breaker closes and latches without trip-free operations. Operate trip control devices to assure that breaker trips open in a reliable manner (6-4.6.3). Functionally test all electrical interlock and safety devices. After satisfactorily passing all operational tests, the breaker may be racked into the "CONNECTED" position and placed in normal service.
Oil-immersed	**Inspection and Maintenance (withdrawn from switchgear and de-energized):**	Maximum of three years or at manufacturer's maximum number of operations since last previous maintenance, whichever occurs first. Immediately after breaker opens to interrupt a fault. Follow manufacturer's maintenance instructions.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 4-Draw-Out Type Circuit Breakers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Oil-immersed (Cont.)	**Inspection and Maintenance (withdrawn from switchgear and de-energized) (Cont.):**	
	Lower oil tank. Inspect, adjust and clean where necessary:	
	Main contacts.	For pitting, spring pressure, overheating, alignment, overtravel or wipe. Adjust or replace accordingly.
	Arcing contacts.	For alignment, overtravel or wipe and for arc erosion. Adjust or replace accordingly.
	Moving parts.	For freedom of movement.
	Closing mechanism.	For quick and positive closing action.
	Tripping mechanism.	For freedom of movement and reliability to open breaker contacts.
	Mechanical interlocks.	Functional test to prove proper operation.
	Primary disconnect finger clusters.	For proper adjustment and spring pressure. Lubricate, unless manufacturer's instructions specify that they should not be lubricated.
	Secondary (control) disconnect contacts.	For alignment and spring pressure. Lubricate.
	Closing and trip coils.	General condition and evidence of overheating.
	Shunt trip device.	For freedom of movement. Functionally test.
	Undervoltage trip device.	For freedom of movement. Functionally test.
	Bushings.	Cracked and chipped porcelain. Condition of surfaces.
	Auxiliary contacts.	For proper operation with closing and opening of breaker.
	Closing (x and y) relays (electrically operated breakers).	Contact erosion. Dress or replace as required.
	Current transformers.	General condition. Check nameplate ratio.
	Connection bolts.	Check for tightness.
	Structure or frame.	For proper alignment and loose or broken parts.
	Fuses and mountings.	General condition and tightness.
	Frame grounding device.	Connect before and disconnect after primary fingers.
	Position indicators.	For proper operation.
	Auxiliary wiring.	General condition and tightness of terminal screws.
	Arc quenchers.	For broken and missing parts and amount of metal spatter and burning on interior surfaces. Repair or replace as necessary.
	Operation counter (if so equipped).	For proper operation. Record number of operations.
	Insulators and insulating materials.	For cracks, breaks and chips. Make necessary repairs.
	Testing (withdrawn from switchgear and de-energized):	Maximum of three years, etc., same as above block.
	Insulation	2500 volt megohmmeter on each main contact with breaker open and all other main contacts and frame grounded. 1000 volt megohmmeter on auxiliary devices and controls and associated wiring.
	Contact conductivity.	Use microhmmeter or determine voltage drop under test load conditions.
	Overcurrent trip devices (electromechanical type).	Pass specified currents from current test set through coils of trip devices to open breaker contacts within time limits according to manufacturer's or specially designed time-current coordination curves. Adjust trip devices as required to accomplish desired results. Test set should be equipped with cycle counter for accuracy of instantaneous trip tests. Record results.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 4-Draw-Out Type Circuit Breakers (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Oil-immersed (Cont.)	**System Testing (breaker installed):** Electrically operated breaker.	After above maintenance has been satisfactorily completed, connect electrically operated breaker to switchgear or test stand control wiring by means of the test cord and plug. Operate closing control devices to assure that breaker closes and latches without trip-free operations. Operate trip control devices to assure that breaker trips open in a reliable manner. Functionally test all electrical interlock and safety devices. After satisfactorily passing all operational tests, the breaker may be placed in its switchgear cell and be racked into the "CONNECTED" position, and placed in normal service.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 5-Buses and Bus Duct

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor	**Inspections (while energized):**	Three to six months.
	Open buses:	
	Condition of bus conductors (6-1.3).	
	Evidence of overheated joints (6-1.3).	Discoloration and/or oxidation indicate possible problem. Infrared survey can be beneficial. Use good quality infrared scanning equipment. Buses should be loaded to at least 30 percent of capacity while being scanned.
	Condition of insulators (6-1.2.1).	Cleanliness and breaks.
	Clearance from grounded metal surfaces and above floor.	
	Loading.	Make certain load is within ampacity rating.
	Bus duct (covers in place):	
	Condition of enclosure (6-2.3).	
	Evidence of water drips on enclosure.	
	Security of switches attached to plug-in type bus duct.	
	Adequate grounding (6-1.5) (6-8.9).	
	Loading.	Make certain load is within ampacity rating.
	Maintenance and Tests (de-energized):	Three to six years.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Open buses:	
	Check connection bolts for tightness (6-1.3).	Torque according to manufacturer's installation instructions.
	Clean insulators and inspect (6-1.2).	Check for cracks, chips and breaks.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 5-Buses and Bus Duct (Continued)

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Indoor (Cont.)	**Maintenance and Tests (de-energized) (Cont.):**	
	Test insulation resistance (18-9.2.1).	2500 volt megohmmeter, if suitable. If not, 1000 volt megohmmeter is satisfactory.
	Bus duct (covers removed):	
	Check condition of bus conductors (6-1.3).	
	Check for evidence of overheated joints (6-1.3) (6-2.14).	Discoloration and/or oxidation indicate possible problem.
	Check connection bolts for tightness (6-1.3).	Torque according to manufacturer's installation instructions.
	Check switches attached to plug-in type bus duct (6-1.5) (6-8.9).	For condition of contacts, operating mechanism, fuse clips, fuses and load cables. Make necessary repairs.
	Check ground connections (6-2.3).	For tightness.
	Check condition of enclosure.	Close all unused holes.
	Check for proper ventilation (6-2.8).	All ventilating louvers should be open.
	Check for evidence of internal moisture (6-2.6).	From water leaks or condensation.
	Clean and inspect insulators (6-1.2).	Check for cracks, chips and breaks.
	Test insulation resistance (18-9.2.1).	Manufacturer usually permits 1000 volt DC test for one minute.
Outdoor	**Inspections (while energized):**	Three to six months.
	Open buses:	
	Same as for indoor open buses.	
	Bus duct (covers in place):	
	Condition of enclosure (6-2.3).	Enclosure should be weatherproof type.
	Adequate grounding (6-1.5) (6-8.9).	
	Loading.	Make certain load is within ampacity rating.
	Maintenance and Tests (de-energized):	Three to six years.
	De-energize (5-3). **Verify that no parts of the power or control circuitry are energized by "back feed" from alternate power or control sources.**	
	Open buses:	
	Same as for indoor open buses.	
	Bus duct (covers removed):	
	Check condition of bus conductors (6-1.3).	
	Check for evidence of overheated joints (6-1.3) (6-2.14).	Discoloration and/or oxidation indicate possible problem.
	Check connection bolts for tightness (6-1.3).	Torque according to manufacturer's installation instructions.
	Check ground connections (6-1.5) (6-8.9).	For tightness.
	Check condition of enclosure (6-2.3).	Close all unused holes. Wire brush and prime paint rust spots. Finish paint.
	Check for evidence of internal moisture (6-2.6).	From water leaks or condensation. Correct.
	Clean and inspect insulators (6-1.2).	For cracks, chips and breaks.
	Test insulation resistance (18-9.2.1).	Manufacturer usually permits 1000 volt DC test for one minute.
	Check operation of space heaters (6-2.7).	Operate during cool weather.
	Check enclosure ventilating louvers (6-2.8).	All ventilating louvers should be open. Should exclude insects, rodents, reptiles and metal rods.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment, 6-Panelboards

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Fused Switch Type	**Inspection (while energized) of:**	Three to six months.
	Switches for overheating (9-4.4).	Feel front of each switch to detect overheating. Arrangements should be made to shut down any overheated switch to determine cause and repair or replace.
	Portion of enclosure over supply cable terminals for overheating (9-3.1) (9-3.2).	Feel enclosure. If overheated, remove cover and inspect supply cables and terminals for evidence of overheating. Discoloration and/or oxidation indicate possible problem.
	Loading.	Constant load on switch should not exceed 80 percent of switch nameplate rating, unless switch is rated for 100 percent continuous operation.
	Enclosure for general condition (9-2).	Arrange to have unused conduit knock-out holes plugged with knock-out closures.
	Ground connections (6-1.5).	For integrity.
	Directory.	For accuracy of loads served.
	Evidence of water dripping on or striking NEMA 1 enclosure.	Stop water leaks.
	Cleaning, Inspection and Maintenance (de-energized) (5-3) (9-4.2):	Three to six years.
	Clean interior of enclosure and switches (9-2).	
	Inspect fuses for overheating (13-1) (9-5).	Refer to Low Voltage Fuse section.
	Inspect fuse clips for overheating and weakness (13-1.2).	Replace weak or burned clips.
	Inspect fuses for proper ampere rating for cable size, and for interrupting adequacy for fault current capability of supply system (13-1.3).	Fuse ampere rating should not exceed NEC ampacity of cables. Fuse interrupting rating should exceed fault current available from system.
	Check connection bolts for tightness (6-2.14).	Do not overtighten and strip threads.
	Check set screws in all cable connectors for tightness(6-1.3).	AL/CU set screw type connectors tend to loosen. Set screws in many old style AL/CU connectors are unplated aluminum on which threads tend to gall and cause set screws to bind before they tighten sufficiently against cables. Replace this connector, if necessary.
	Open and close switches. Inspect contact surfaces and operating mechanism (9-4.5).	Repair or replace burned contacts. Make certain switch contacts close fully.
	Inspect all insulating materials (6-2.10 & 6-2.14).	For cracks, breaks, cleanliness and thermal damage.
	Inspect arc chutes.	For broken parts and missing arc splitters.
	Check door/switch mechanical interlocks (9-9.3).	That switch door cannot be opened when switch handle is in "ON" position — unless interlock defeater mechanism is operated. That switch handle cannot be thrown to "ON" position while switch door is open — unless interlock defeat mechanism is operated.
	Check padlock devices (9-9.5).	That switch handle cannot be thrown to "ON" position with padlock in lockout device.
	Check door latches.	That doors do not open when operating handle is in "ON" position.
	Check directory for accuracy.	
	Enclosure (9-2).	Wire brush and prime paint rust spots. Finish paint.
	Test supply cables, switches and load cables for insulation resistance (18-9.2.1).	2500 volt megohmmeter preferred — 1000 volt megohmmeter acceptable.
Molded Case Circuit Breaker-type (Chapter 10) (18-10)	Inspections and maintenance similar to fused switch type except: Circuit breakers usually cannot be opened for inspection and maintenance. Breakers usually operate at a higher temp. Breakers usually contain no fuses. Breakers often not equipped with external door or operating handle other than handle integral with breaker. Breaker overcurrent trip operation can be tested with high current test set (18-10).	Three to six years.

Maintenance of Equipment Subject to Long Intervals Between Shutdowns — Electrical Distribution, H-4 Low Voltage Equipment

7-Protective Relays

Type	Inspections, Maintenance and Tests	Typical Frequency and Remarks
Induction Disk (18-10.3)	Same as for Medium Voltage Protective Relays.	Refer to Medium Voltage Protective Relays sections.
	8-Automatic Transfer Control Equipment	
Indoor and Outdoor	Same as for Medium Voltage Auto Transfer Control Equipment.	Refer to Medium Voltage Auto Transfer Equipment section.
	9-Circuit Breaker Overcurrent Trip Devices	
Series and 5 Amp Type (18-10.2.9)	Same as O.C. Trip item in Low Voltage Draw-out Circuit Breaker section.	Refer to Low Voltage Draw-out Circuit Breaker section.
	10-Fuses	
Cartridge and Plug Type (13-1)	Same as for Medium Voltage Fuses except: Inspect for discoloration or charring of fiber barrel ends adjacent to ferrules (6-2.14). Check for assembly tightness of renewable fuse ferrules on barrels (6-1.3). Check for constant moderate overload on circuit supplied by fuses.	Refer to Medium Voltage Fuse section. This may be done while fuses are energized. Indicates probability of loose contact between fuse ferrules or blades and spring clips. Looseness can possibly cause overheating of ferrules and fiber barrel ends. Fuses should not be continuously loaded beyond 80 percent of ampere rating.
	11-Lightning Arresters	
Indoor and Outdoor Type (6-8.2)	Same as for Medium Voltage Lightning Arresters except: Test insulation resistance. Arresters in metal containers.	Refer to Medium Voltage Lightning Arrester section. Use 500 volt megohmmeter. Inspect conductors for damage where they enter container.