

NFPA®

70B

Standard for
Electrical Equipment Maintenance

2023



NFPA® 70B

Standard for Electrical Equipment Maintenance

2023 Edition



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NFPA® 70B

Standard for

Electrical Equipment Maintenance

2023 Edition

This edition of NFPA 70B, *Standard for Electrical Equipment Maintenance*, was prepared by the Technical Committee on Electrical Equipment Maintenance and released by the Correlating Committee on National Electrical Code®. It was issued by the Standards Council on December 27, 2022, with an effective date of January 16, 2023, and supersedes all previous editions.

This edition of NFPA 70B was approved as an American National Standard on January 16, 2023.

Origin and Development of NFPA 70B

The National Electrical Code Committee had received several requests to include maintenance recommendations in the *National Electrical Code® (NEC®)*. The National Electrical Code Correlating Committee determined that the *NEC* was not the proper document in which to cover the maintenance of electrical equipment. However, the committee recognized that “lack of maintenance” frequently resulted in serious injuries and fatalities as well as high monetary damage. An ad hoc committee on electrical equipment maintenance was authorized by NFPA in 1967 to determine the need for the development of a document on the subject.

Equipment manufacturers typically provide maintenance needs for specific types of equipment, and general maintenance guidance was available from several sources. Therefore, it was determined that compiling that information into a single document under the NFPA process in the form of general guidelines was advantageous.

On June 27, 1968, NFPA authorized the establishment of the Committee on Electrical Equipment Maintenance with the following scope: “To develop suitable texts relating to preventive maintenance of electrical systems and equipment used in industrial-type applications with the view of reducing loss of life and property. The purpose is to correlate generally applicable procedures for preventive maintenance that have broad application to the more common classes of industrial electrical systems and equipment without duplicating or superseding instructions that manufacturers normally provide. Reports to the Association through the Correlating Committee of the National Electrical Code Committee.”

In 1973, NFPA 70B-T, *Tentative Recommended Practice for Electrical Equipment Maintenance*, covered “Why an Electrical Preventive Maintenance (EPM) Program Pays Dividends,” “What Is an Effective Electrical Preventive Maintenance Program?,” and “Planning and Developing an Electrical Preventive Maintenance Program.” The document was revised in 1974 to include a chapter on the fundamentals of electrical equipment maintenance, general maintenance requirements for various types of equipment, and a new appendix, “How to Instruct.” The tentative recommended practice was adopted as NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, in 1975.

For the 1977 edition, added chapters included Electronic Equipment, Ground-Fault Protection, Wiring Devices, and Maintenance of Electrical Equipment Subject to Long Intervals Between Shutdowns. New appendices addressed NEMA plug and receptacle configurations and guidelines for long-term maintenance.

In the 1983 edition, chapters on cable tray systems and on deenergizing and grounding of equipment to provide protection for maintenance personnel were added. An appendix covering equipment storage and maintenance during construction was also added.

The 1987 edition included distribution transformers as well as power transformers.

A chapter on uninterruptible power supply systems was added in the 1990 edition.

Three new chapters were added to the 1994 edition to cover power system studies, power quality, and vibration analysis pertaining to rotating machinery. Other revisions were made to comply with the NFPA *Manual of Style*.

For the 1998 edition, the chapter on power quality was rewritten and expanded. Maintenance techniques for stationary batteries and infrared inspections were updated and revised. Special handling and disposal considerations were introduced, and employee training was focused to emphasize workplace safety.

The 2002 edition was restructured to comply with the *Manual of Style for NFPA Technical Committee Documents*. The scope was revised to include preventive maintenance for electronic and communications equipment. A chapter was added for grounding maintenance issues. A new section for gas insulated substations addressed the maintenance issues resulting from regulatory changes in the electrical utility industry.

The chapter on power quality was enhanced with information on the latest technology on voltage fluctuation. A new annex suggested maintenance intervals for electrical equipment.

The 2006 edition included a new chapter on safety placed up front to provide more complete and updated coverage, as well as to emphasize the importance of safety. An important part of maintenance is having a properly installed system with baseline performance data, and so a chapter on commissioning the electrical system at a new facility was added. With the industry trend shifted from routine maintenance to reliability-centered maintenance (RCM), a chapter on how to apply RCM and an extensive annex with detailed reliability data on many types of electrical equipment also was added.

The 2010 edition was reorganized to group like topics and equipment into a more logical arrangement. The chapter on testing and test methods centralized test procedures formerly located in the individual equipment chapters.

A section on emergency preparedness and electrical system and equipment restoration was added to Chapter 6 to respond to the concerns of electrical equipment owners and maintainers. Chapter 6 included new material covering outsourcing of electrical equipment maintenance. The requirements on personnel safety were revised to correlate with and directly reference NFPA 70E.

Significant material supporting reliability centered maintenance was added to Annex N.

Four new chapters were added to the 2013 edition: Chapter 32, Electrical Disaster Recovery; Chapter 33, Photovoltaic Systems; Chapter 34, Electrical Vehicle Charging Systems; and Chapter 35, Wind Power Electrical Systems and Associated Equipment.

For the 2016 edition, torque recommendations were added to assist in minimizing electrical issues associated with poor connections. Battery testing and maintenance recommendations were enhanced to provide greater detail regarding proper battery testing and safety considerations for persons performing battery maintenance.

The 2019 edition incorporated several editorial and stylistic updates to improve the consistency of the document.

The recommended practice has been converted to the *Standard for Electrical Equipment Maintenance* standard for the 2023 edition.

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Committee Scope: This Committee shall have the primary responsibility for documents relating to preventive maintenance of electrical, electronic, and communications systems and equipment used in industrial and commercial type applications with the view of: (1) reducing loss of life and property, and (2) improving reliability, performance, and efficiency in a cost-effective manner. The purpose is to provide generally applicable procedures for preventive maintenance that have broad application to the more common classes of industrial and commercial systems and equipment without duplicating or superseding instructions that manufacturers normally provide. This Committee shall report to Correlating Committee of the National Electrical Code.

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NFPA 70B

Standard for

Electrical Equipment Maintenance

2023 Edition

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A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex R.

Chapter 1 Administration

1.1 Scope. This standard covers the preventive maintenance of electrical, electronic, and communications systems and equipment.

1.2 Purpose. The purpose of this standard is to provide for the practical safeguarding of persons, property, and processes from the risks associated with failure, breakdown, or malfunction and a means to establish a condition of maintenance of electrical equipment and systems for safety and reliability.

1.3 Application.

1.3.1 This standard applies to maintenance for electrical, electronic, and communications systems and equipment and is not intended to duplicate or supersede instructions provided by manufacturers. Systems and equipment covered are typical of those installed for industrial plants, institutional and commercial buildings, and large multifamily residential complexes.

1.3.2 Consumer appliances and equipment intended primarily for use in the home are not covered.

1.4 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, effectiveness, and safety over those prescribed by this standard.

1.5 Units of Measurement.

1.5.1 Primary Units. Primary units of measurement are in accordance with the modernized metric system known as the International System of Units (SI), except where specific units are customary for industry practice.

1.5.2 Secondary Units and Conversions.

1.5.2.1 Secondary units of measurement, where provided, are in accordance with US customary units (inch-pound units), except where specific units are customary for industry practice.

1.5.2.2 Where secondary units are not provided, converted values and converted trade sizes can be used.

1.5.2.3 Where extracted text contains values expressed in only one system of units, the values in the extracted text have been retained without conversion to preserve the values established by the responsible technical committee in the source document.

1.5.3 Unit Application and Enforcement.

1.5.3.1 The values presented in this standard are expressed with a degree of precision that is appropriate for practical application and enforcement.

1.5.3.2* Either the primary units or secondary units are acceptable for satisfying the requirements in this standard.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. (Reserved)

2.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 70®, National Electrical Code®, 2023 edition.

NFPA 70E®, Standard for Electrical Safety in the Workplace®, 2021 edition.

Chapter 3 Definitions

3.1 General.

3.1.1 The definitions contained in this chapter shall apply to the terms used in this standard.

3.1.2 Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used.

3.1.3 Merriam-Webster's Collegiate Dictionary, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Standard. An NFPA standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases “standards development process” or “standards development activities,” the term “standards” includes all NFPA standards, including codes, standards, recommended practices, and guides.

3.3 General Definitions.

3.3.1* Adjustable Speed Drive. Power conversion equipment that provides a means of adjusting the speed of an electric motor. [70, 2023]

3.3.2 Appliance. Utilization equipment, generally other than industrial, that is fastened in place, stationary, or portable; is normally built in a standardized size or type; and is installed or connected as a unit to perform one or more functions such as clothes washing, air-conditioning, food mixing, deep frying, and so forth. [70, 2023]

3.3.3 Arc Flash Hazard. A source of possible injury or damage to health associated with the release of energy caused by an electric arc. [70E, 2021]

3.3.4 Bonded (Bonding). Connected to establish electrical continuity and conductivity. [70, 2023]

3.3.5 Bonding Conductor (Bonding Jumper). A conductor that ensures the required electrical conductivity between metal parts that are required to be electrically connected. [70, 2023]

3.3.6 Bonding Jumper, Equipment. The connection between two or more portions of the equipment grounding conductor. [70, 2023]

3.3.7 Busway. A raceway consisting of a metal enclosure containing factory-mounted, bare or insulated conductors, which are usually copper or aluminum bars, rods, or tubes. [70, 2023]

3.3.8 Cable Tray System. A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways. [70, 2023]

3.3.9* Circuit Breaker. A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [70, 2023]

3.3.10 Commissioning. The process, procedures, and testing used to set up and verify the initial performance, operational controls, safety systems, and sequence of operation of electrical devices and equipment, prior to it being placed into active service. [70, 2023]

3.3.11 Condition of Maintenance. The state of the electrical equipment considering the manufacturers’ instructions, manufacturers’ recommendations, and applicable industry codes, standards, and recommended practices. [70E, 2021]

3.3.12 Continuous Monitoring. An uninterrupted method of data collection that utilizes permanently mounted counters, sensors, or controllers to measure a condition or state.

3.3.13 Coordination Study. A system planning process used to assist in selecting and setting protective devices to improve power system reliability.

3.3.14* Corona. An electrical discharge phenomenon occurring in gaseous substances, such as air.

3.3.15 Disconnecting Means. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [70, 2023]

3.3.16* Electrical Maintenance Program (EMP). A managed program of inspecting, testing, monitoring, analyzing, and servicing electrical systems and equipment with the purpose of maintaining safe operations and production by reducing or eliminating system interruptions and equipment failures.

3.3.17 Electrically Safe Work Condition. A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection. [70E, 2021]

3.3.18 EMP Coordinator. The individual responsible for coordinating the implementation and operation of the EMP.

3.3.19* Energy Storage System (ESS). One or more devices installed as a system capable of storing energy and providing electrical energy into the premises wiring system or an electric power production and distribution network. [70, 2023]

3.3.20 Equipment, Mobile (Mobile Equipment). Equipment with electrical components that is suitable to be moved only with mechanical aids or is provided with wheels for movement by a person(s) or powered devices. [70, 2023]

- N 3.3.21* Fault Current, Available (Available Fault Current).** The largest amount of current capable of being delivered at a point on the system during a short-circuit condition. [70, 2023]
- 3.3.22 Ground.** The earth. [70, 2023]
- 3.3.23 Grounded (Grounding).** Connected (connecting) to ground or to a conductive body that extends the ground connection. [70, 2023]
- 3.3.24 Grounded Conductor.** A system or circuit conductor that is intentionally grounded. [70, 2023]
- 3.3.25 Ground Fault.** An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metal enclosures, metal raceways, metal equipment, or earth. [70, 2023]
- 3.3.26* Ground-Fault Circuit Interrupter (GFCI).** A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a ground-fault current exceeds the values established for a Class A device. [70, 2023]
- Δ 3.3.27* Ground-Fault Protection of Equipment.** A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device. [70, 2023]
- N 3.3.28 Grounding Conductor, Equipment (EGC).** A conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. [70, 2023]
- 3.3.29 Grounding Electrode.** A conducting object through which a direct connection to earth is established. [70, 2023]
- 3.3.30 Grounding Electrode Conductor.** A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. [70, 2023]
- 3.3.31 Grounding Electrode System.** The interconnection of grounding electrodes.
- 3.3.32 Grounding Terminal.** A terminal, lug, or other provision provided on some equipment cases (enclosures) to connect the conductive portion of the enclosure to the equipment-grounding conductor.
- Δ 3.3.33* Ground Loop.** Multiple intentional or unintentional connections from a conductive path to ground or the conductive body that serves in place of earth.
- 3.3.34 Harmonics.** Voltages or currents whose frequencies are integer multiples of the fundamental system frequency.
- 3.3.35* Interharmonics.** Voltages or currents whose frequencies are not integer multiples of the fundamental system frequency.
- 3.3.36* Long-Duration Undervoltage.** A decrease of the supply voltage to less than 90 percent of the nominal voltage for a time duration greater than 1 minute.
- N 3.3.37 Maintenance Interval.** The frequency of inspecting, testing, monitoring, analyzing, and servicing electrical equipment that is determined by the type, criticality, and condition of the equipment.
- N 3.3.38 Motor Control Center.** An assembly of one or more enclosed sections having a common power bus and principally containing motor control units. [70, 2023]
- 3.3.39 Noise.** Undesirable electrical signals in an electrical or electronic circuit.
- Δ 3.3.39.1 Noise, Common Mode.** Undesirable electrical signals that exist between a circuit conductor and the grounding conductor.
- N 3.3.40 Overcurrent.** Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault. [70, 2023]
- N 3.3.41 Overcurrent Protective Device, Branch-Circuit (Branch-Circuit Overcurrent Protective Device).** A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating. [70, 2023]
- N 3.3.42 Overload.** Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of its ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. [70, 2023]
- N 3.3.43 Panelboard.** A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet, enclosure, or cutout box placed in or against a wall, partition, or other support; and accessible only from the front. [70, 2023]
- N 3.3.44 Portable Equipment.** Equipment with electrical components suitable to be moved by a single person without mechanical aids. [70, 2023]
- N 3.3.45 Power Quality.** Electrical phenomena that can be used to quantify the quality of the electrical supply, including, but not limited to, voltage transients, voltage sags, voltage swells, voltage interruptions, voltage and current harmonics, voltage fluctuations resulting in light flicker, voltage and current unbalance, power frequency deviations, voltage and current interharmonics, and electrical noise (conducted or radiated).
- N 3.3.46 Predictive Techniques.** Analytics, algorithms, or software that interpret and analyze data from input sources and provide recommendations to address identified problems.
- Δ 3.3.47 Qualified Person.** One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk. [70E, 2021]
- N 3.3.48* Reconditioned.** Electromechanical systems, equipment, apparatus, or components that are restored to operating conditions. This process differs from normal servicing of equipment that remains within a facility, or replacement of listed equipment on a one-to-one basis. [70, 2023]
- 3.3.49 Risk Assessment.** An overall process that identifies hazards, estimates the likelihood of occurrence of injury or

damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required. [70E, 2021]

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- Δ 3.3.50* **Sag.** A decrease to between 10 percent and 90 percent of the normal voltage at the power frequency for durations of 0.5 cycle to 1 minute.
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- N 3.3.51* **Service Point.** The point of connection between the facilities of the serving utility and the premises wiring. [70, 2023]

- N 3.3.52* **Servicing.** The process of following a manufacturer's set of instructions or applicable industry standards to analyze, adjust, or perform prescribed actions upon equipment with the intention to preserve or restore the operational performance of the equipment. [70, 2023]

- N 3.3.53 **Single-Line Diagram.** A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system. [70E, 2021]

- N 3.3.54* **Ground-Fault Circuit Interrupter, Special Purpose (SPGFCI). (Special-Purpose Ground-Fault Circuit Interrupter)** A device intended for the detection of ground-fault currents, used in circuits with voltage to ground greater than 150 volts, that functions to de-energize a circuit or portion of a circuit within an established period of time when a ground-fault current exceeds the values established for Class C, D, or E devices. [70, 2023]

- N 3.3.55* **Stationary Standby Battery.** A battery that spends the majority of the time on continuous float charge or in a high state of charge, in readiness for a discharge event.

3.3.56* **Survey.** The collection of accurate data on the electrical system and the evaluation of this data to obtain the necessary information for developing the EMP.

3.3.57 **Sustained Voltage Interruption.** The loss of the supply voltage to less than 10 percent on one or more phases for a period greater than 1 minute.

- Δ 3.3.58 **Swell.** An increase to between 110 percent and 180 percent of the normal voltage at the power frequency for durations from 0.5 cycle to 1 minute.
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- N 3.3.59* **Switchboard.** A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. [70, 2023]

- N 3.3.60* **Switchgear.** An assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows) and containing primary power circuit switching, interrupting devices, or both, with buses and connections. The assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both. [70, 2023]

N 3.3.61 Tests.

- N 3.3.61.1* **Acceptance Tests.** Tests that are performed on new equipment prior to energization to determine whether the equipment complies with the purchase and design specifications.

- N 3.3.61.2 **As-Found Tests.** Tests performed on equipment before maintenance work is performed.

- N 3.3.61.3 **As-Left Tests.** Tests performed on equipment after maintenance work is performed.

- N 3.3.61.4* **Enhanced Tests.** Tests performed on equipment that is thought or known to be defective or equipment that has been subjected to conditions that could adversely affect its condition or operating characteristics.

- N 3.3.61.5 **Standard Tests.** Tests that are performed at regular intervals over the service life of equipment, typically in conjunction with maintenance on the equipment.

3.3.62 **Transformer.** Equipment, either single-phase or poly-phase, that uses electromagnetic induction to convert current and voltage in a primary circuit into current and voltage in a secondary circuit. [70, 2023]

- N 3.3.62.1 **Transformer, Power.** A transformer rated greater than 500 kVA.

- Δ 3.3.63* **Transients.** Very short duration, high amplitude excursions outside of the limits of the normal voltage and current waveform.

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- 3.3.64 **Unbalanced Voltages.** Unequal voltage values on 3-phase circuits that can exist anywhere on the power distribution system.
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- N 3.3.65 **Utilization Equipment.** Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [70, 2023]
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N Chapter 4 General

N 4.1 General Requirements.

- N 4.1.1 Electrical equipment shall be maintained in accordance with the manufacturer's instructions and applicable codes and standards.

- N 4.1.2 This standard is not intended to duplicate or supersede manufacturer's instructions.

- N 4.1.3 In the absence of manufacturer's instructions, equipment shall be maintained in accordance with industry consensus standards.

N 4.2 Electrical Maintenance Program (EMP).

- N 4.2.1 **General.** The equipment owner shall implement and document an overall EMP that directs activity appropriate to the safety and operational risks.

N 4.2.2 Inspection.

- N 4.2.2.1 The EMP shall include elements to verify that electrical equipment or systems have been inspected to comply with applicable installation codes and standards.

- N 4.2.2.2 Equipment-specific maintenance tasks shall be developed utilizing the information gathered during the inspection.

- N 4.2.3 **Condition of Maintenance.** The EMP shall include elements that consider current condition of maintenance of electrical equipment and systems as well as the potential safety and operational risks to maintenance and operational personnel.

- N 4.2.4 **EMP Principles.** The EMP shall identify the principles upon which it is based and the goals to be achieved.

N 4.2.4.1 The EMP shall be designed to function in conjunction with the applicable electrical safety program.

N 4.2.4.2* The EMP shall include the following elements:

- (1) An electrical safety program that addresses the condition of maintenance
- (2) Identification of personnel responsible for implementing each element of the program
- (3) Survey and analysis of electrical equipment and systems to determine maintenance requirements and priorities
- (4) Developed and documented maintenance procedures for equipment
- (5) A plan of inspections, servicing, and suitable tests
- (6) A maintenance, equipment, and personnel documentation and records-retention policy
- (7) A process to prescribe, implement, and document corrective measures based on collected data
- (8) A process for incorporating design for maintainability in electrical installations
- (9) A program review and revision process that considers failures and findings for continuous improvement

N 4.2.5 EMP Controls. The EMP shall identify the controls by which it is measured and monitored.

N 4.2.6 Incident Investigations. The EMP shall include a method to utilize all associated reports for feedback and EMP refinement, including the following:

- (1) Electrical safety incidents
- (2) Equipment malfunctions
- (3) Unintended operations or alarms
- (4) Operation of protective devices

N 4.2.7 EMP Audit. The EMP shall be audited at intervals not to exceed 5 years to verify that the principles and procedures of the EMP comply with this standard.

N 4.3 Personnel.

N 4.3.1 EMP Coordinator. The EMP shall identify an EMP coordinator.

N 4.3.2 Maintenance Personnel. Personnel assigned to EMP duties shall be qualified for the assigned tasks.

N 4.3.3 Electrical Maintenance Training. A qualified person responsible for conducting electrical maintenance shall be trained in the specific maintenance tasks, test methods, test equipment, PPE usage (as applicable), and hazards associated with the electrical equipment or system being serviced.

N 4.3.3.1 A person who is undergoing on-the-job training for the purpose of obtaining the skills and knowledge necessary to be considered a qualified person, and who in the course of such training demonstrates an ability to perform specific duties safely at his or her level of training, and who is under the direct supervision of a qualified person shall be considered to be a qualified person for the performance of those specific duties.

N 4.3.3.2 The employer shall determine through regular supervision or through inspections conducted on at least an annual basis that each employee is complying with the electrical maintenance procedures and testing required by this standard.

N 4.3.3.3 A person responsible for conducting electrical maintenance shall be provided additional training (or retraining) if any of the following conditions exists:

- (1) The supervision or annual inspections indicate the person is not complying with the maintenance procedures and testing requirements.
- (2) New technology, new types of equipment, or changes in procedures necessitate the use of maintenance procedures and testing requirements different from those that the person would normally use.
- (3) The person needs to review tasks that are performed less often than once per year.
- (4) The person needs to review maintenance procedures and testing requirements that they do not normally use during regular job duties.
- (5) The person's job duties change.
- (6) A new edition of this standard is adopted that includes changes applicable to the person's job duties.

N 4.3.3.4 Training shall be documented in accordance with the following:

- (1) Documentation shall be issued when the person demonstrates proficiency in the electrical maintenance procedures and testing requirements.
- (2) Documentation shall be retained for the duration of the person's employment.
- (3) Documentation shall specify the content of the training, the person's name, and the dates of training.

N 4.4 Survey and Analysis.

N 4.4.1 The EMP coordinator shall determine the scope of the work to be performed and develop a prioritized plan for the electrical maintenance of the electrical equipment or system.

N 4.4.2 Electrical equipment and systems shall be evaluated to determine the appropriate scope and frequency of maintenance.

N 4.4.3 Environmental, physical, or operating conditions of a specific installation shall be considered in determining the frequency of electrical maintenance.

N 4.5 Planned Inspections. The following considerations shall be reviewed during development of planned inspections:

- (1) Potential of equipment failure to endanger or threaten personnel safety
- (2) Manufacturer's recommended service and maintenance practices and procedures
- (3) Operating environment
- (4) Operating load conditions and equipment rating
- (5) Failure and repair of equipment causing extensive downtime and lost production dollars
- (6) Equipment condition
- (7) Production and operating schedules
- (8) Failure history
- (9) Inspection history

N 4.6 Acceptance Test Report. A copy of the acceptance test reports, if available, shall be included with the maintenance records.

N 4.7 Impact of Additions/Rework to Retrofitting Equipment.

N 4.7.1* Safety certifications shall be maintained for repaired or rebuilt equipment.

N 4.7.2* When repairing, rebuilding, or remanufacturing equipment, the work shall be conducted by a qualified person or organization to assure that no changes are made to the equip-

ment that might prevent the equipment from meeting the applicable performance and safety requirements.

N 4.7.3 Refurbished or remanufactured equipment shall be marked to identify it as such.

N 4.8* Equipment Cleaning. Electrical equipment cleaning shall be a part of the EMP.

N 4.8.1 Cleaning Personnel.

N 4.8.1.1 Electrical equipment cleaning shall be performed by personnel who are familiar with the cleaning materials required and methodologies necessary for effective removal of contaminants, debris, and other foreign materials that compromise electrical equipment performance.

N 4.8.1.2 The persons assigned to the task of electrical equipment cleaning shall be trained in the following:

- (1) Potential damage to the equipment from cleaning procedures
- (2) Potential personal injury
- (3) Specific cleaning procedures
- (4) Equipment not to be cleaned

N Chapter 5 Personnel Safety

N 5.1 Introduction.

N 5.1.1 Electrical maintenance shall be performed only by qualified persons.

N 5.1.2* Electrical safety-related work practices shall be instituted and followed, in accordance with applicable state, federal, or local codes and standards, to identify the hazards and reduce the associated risks.

N Chapter 6 Single-Line Diagrams and System Studies

N 6.1 Introduction.

N 6.1.1* System studies shall be completed in accordance with this chapter.

N 6.1.2 Single-line diagrams shall be maintained in accordance with this chapter.

N 6.2 Single-Line Diagrams. Up-to-date single-line diagrams shall be the primary reference for system studies.

N 6.2.1 Single-line diagrams shall be maintained in a legible condition.

N 6.2.2 Single-line diagrams shall be kept accurate.

N 6.2.3 Single-line diagram shall indicate the date of the last revision.

N 6.2.4 When single-line diagrams are not available, the facility or equipment owner shall be responsible for providing an equally effective means of obtaining the necessary information.

N 6.3* Short-Circuit Studies.

N 6.3.1 Where a short-circuit study does not exist, one shall be created, as necessary to support the arc-flash risk assessment and equipment evaluations.

N 6.3.2 The short-circuit study shall be updated when changes occur in the electrical distribution system that could affect the results of the study.

N 6.3.3 The short-circuit study shall be reviewed for accuracy at intervals not to exceed 5 years.

N 6.3.4 The most recent study shall be made available to the EMP coordinator.

N 6.3.5 When the short-circuit study is updated, an electrical equipment rating evaluation shall be completed for the equipment within the scope of the study.

N 6.4* Coordination Studies.

N 6.4.1 A coordination study shall be created as necessary to support risk assessments and the intended system design goals.

N 6.4.2 The coordination study shall be updated when changes occur in the electrical distribution system that could affect the results of the study.

N 6.4.3 The coordination study shall be reviewed for accuracy at intervals not to exceed 5 years.

N 6.4.4 The most recent study shall be made available to the EMP coordinator.

N 6.4.5 When the coordination study is updated, the electrical equipment overcurrent protective devices and equipment ratings shall be reviewed and verified for the equipment within the scope of the study.

N 6.5* Load-Flow Studies.

N 6.5.1 If a load-flow study is needed to allow maintenance to be performed, the load-flow study shall be updated when changes occur that could affect the results of the study.

N 6.5.2 The load-flow study shall be reviewed for accuracy at intervals not to exceed 5 years.

N 6.5.3 The most recent study shall be made available to the EMP coordinator.

N 6.6* Reliability Studies.

N 6.6.1 A reliability study shall be conducted as necessary on critical or important facility electrical systems to identify equipment and circuit configurations that can lead to unplanned outages.

N 6.6.2 Spare parts shall be monitored and inspected periodically to ensure that they will be available when needed.

N 6.6.3 The reliability study shall be reviewed for accuracy at intervals not to exceed 5 years.

N 6.6.4 The study shall be kept current and revised whenever a significant change to the electrical system has been made.

N 6.7* Incident Energy Analysis (Arc-Flash Study).

N 6.7.1 The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis.

N 6.7.2 The analysis shall be reviewed for accuracy at intervals not to exceed 5 years.

N 6.7.3 The most recent study shall be made available to the EMP coordinator.

N 6.8* Electrical Maintenance-Related Design. Where a recognized hazard presents an increased risk during maintenance, a study shall be conducted to develop design options that could be implemented to reduce risk.

N Chapter 7 Fundamental Tests

N 7.1 Fundamental Tests. The fundamental test procedures described in this chapter shall be used where required elsewhere in this standard.

N 7.2 Bolted Bus Connections, Conductor Terminations, and Conductor Connectors.

N 7.2.1 The quality of undisturbed bolted electrical bus connections, conductor terminations, and conductor connectors shall be verified using one or more of the methods described in 7.2.1.1 through 7.2.1.4.

N 7.2.1.1 Infrared Thermographic Inspection of Electrical Connections. Infrared thermographic inspection of electrical connections and terminations shall be performed in accordance with Section 7.4.

N 7.2.1.2 Thermal Sensors. Permanently mounted thermal sensors shall be permitted to monitor the temperature of electrical connections and terminations.

N 7.2.1.3 Contact Resistance Test.

N 7.2.1.3.1 A calibrated tester shall be used to obtain contact resistance test values.

N 7.2.1.3.2 Where contact resistance tests are used, the resistance values shall not exceed the maximum values published by the manufacturer.

N 7.2.1.3.3 If contact resistance values exceed the maximum values published by the manufacturer, the cause for the excess values shall be investigated.

N 7.2.1.4 Torque Verification.

N 7.2.1.4.1 When using a calibrated torque wrench to confirm the torque of previously installed threaded hardware, the retightening value shall not exceed 90 percent of the manufacturer's specified initial torque value.

N 7.2.1.4.2 Where initial threaded hardware torque value data is not available, torque values shall be in accordance with Table 7.2.1.4.2(a), Table 7.2.1.4.2(b), or Table 7.2.1.4.2(c).

N 7.2.2 Newly Installed Threaded Hardware Torque Values.

N 7.2.2.1 Newly installed threaded hardware connections shall be torqued to the manufacturer's published data.

N 7.2.2.2 Where the manufacturer's data is not available, torque values shall be in accordance with Table 7.2.1.4.2(a), Table 7.2.1.4.2(b), or Table 7.2.1.4.2(c) based on the hardware used.

N 7.3 Insulation Resistance Quality.

N 7.3.1 For equipment rated up to 1000 volts, the quality of electrical insulation (insulation resistance) shall be verified using a dc insulation resistance test set.

N 7.3.1.1 Insulation Resistance Testing. The applied test voltage shall not exceed the value specified by the manufacturer.

N Table 7.2.1.4.2(a) Bolt-Torque Values for Electrical Connections, US Standard Fasteners — Cadmium or Zinc Plated

Bolt Diameter (in.)	Torque (Pound-Feet)
1/4	6
5/16	11
3/8	20
7/16	32
1/2	48
9/16	70
5/8	96
3/4	160
7/8	240
1.0	370

Notes:

- (1) Consult the manufacturer for equipment supplied with metric fasteners.
- (2) The table is based on national coarse thread pitch.
- (3) The grade is SAE 5.
- (4) The minimum tensile (strength) is 105,000 lbf/in.².

N Table 7.2.1.4.2(b) Bolt-Torque Values for Electrical Connections, US Standard Fasteners — Silicon Bronze

Bolt Diameter (in.)	Torque (Pound-Feet)	
	Nonlubricated	Lubricated
5/16	15	10
3/8	20	15
1/2	40	25
5/8	55	40
3/4	70	60

Notes:

- (1) Consult the manufacturer for equipment supplied with metric fasteners.
- (2) This table is based on national coarse thread pitch.
- (3) This table is based on bronze alloy bolts having a minimum 70,000 lb/in.² tensile strength.

N Table 7.2.1.4.2(c) Bolt-Torque Values for Electrical Connections, US Standard Fasteners — Aluminum

Bolt Diameter (in.)	Torque (Pound-Feet), Lubricated
5/16	10
3/8	14
1/2	25
5/8	40
3/4	60

Notes:

- (1) Consult the manufacturer for equipment supplied with metric fasteners.
- (2) This table is based on national coarse thread pitch.
- (3) This table is based on aluminum alloy bolts having a minimum 55,000 lb/in.² tensile strength.

N 7.3.1.1.1 Where manufacturer's value is not available, test voltage shall be in accordance with appropriate industry standard.

N 7.3.1.1.2 The test instrument used to perform an insulation-resistance test shall be calibrated.

N 7.3.2 For equipment rated in excess of 1000 volts, the electrical insulation quality test method shall be determined by the EMP.

N 7.3.2.1 The test method shall be one or more of the following:

- (1) dc insulation resistance
- (2) ac or dc dielectric withstand testing
- (3) dc overpotential (hipot) testing
- (4) ac insulation power factor/dissipation factor testing
- (5) Very low frequency (VLF) testing
- (6) Damped alternating current (DAC) voltage test
- (7) Acoustical ultrasonic testing
- (8) Partial discharge (PD) testing

N 7.4 Infrared Thermography.

N 7.4.1 Infrared thermography shall be used when required to verify temperature differences (ΔT) of the following:

- (1) Similar electrical components under similar loading
- (2) Comparison between electrical components and ambient air temperatures

N 7.4.2 All accessible and necessary covers shall be removed prior to infrared thermography inspection to provide a clear line of sight to the equipment being scanned.

N 7.4.3 Temperature differences between the area of concern and the reference area shall be documented.

N 7.4.4 Infrared thermography inspections shall be performed at normal circuit loading.

N 7.4.5 Where normal circuit loading is not feasible, circuit loading of not less than 40 percent of nominal circuit loading shall be permitted.

N 7.4.6 Circuit loading characteristics shall be documented and retained for future reference.

N Chapter 8 Field Testing and Test Methods

N 8.1 Introduction. Field testing and test methods shall be conducted in accordance with this chapter to assess the overall condition of electrical equipment and systems and to accomplish the following objectives:

- (1) Ascertain the ability of the device under test to continue to perform its function as designed
- (2) Determine whether any corrective maintenance or replacement is necessary
- (3) Document the condition of the equipment over its service life
- (4) Provide results to ascertain the overall condition of maintenance of the device under test

N 8.2 Risk Assessment Special Considerations. Where the following special considerations are present, a risk assessment shall be performed to identify hazards and determine if additional protective measures are required prior to beginning work:

- (1) Electrical, as follows:

- (a) X-ray
- (b) Overpotential
- (2) Mechanical, as follows:
 - (a) Stored energy
 - (b) Mass energy
- (3) Chemical, as follows:
 - (a) SF₆ gas fault by-products
 - (b) Electrolytes
- (4) Environmental, as follows:
 - (a) Asbestos
 - (b) SF₆ gas
 - (c) Insulating fluids, as follows:
 - (i) PCBs
 - (ii) Tetrachloroethylene

N 8.3* Testing Category Types. Electrical maintenance testing tasks shall be identified as one of the following category types:

- (1) Category 1 — Online standard test
- (2) Category 1A — Online enhanced test
- (3) Category 2 — Offline standard test
- (4) Category 2A — Offline enhanced test

WARNING: Testing of electrical equipment while it is connected to the source of supply introduces additional hazards to the worker. Workers should understand the hazards and risks of the test being performed.

N 8.3.1 Category 1 — Online Standard Test. Online standard tests shall include testing procedures performed while the electrical equipment or device is connected to the source of supply.

N 8.3.2 Category 1A — Online Enhanced Test. Online enhanced tests shall include certain testing procedures performed while the electrical equipment or device is connected to the source of supply and that are not typically performed in normal electrical maintenance activities and that provide additional diagnostic information. (See A.8.3.)

N 8.3.3 Category 2 — Offline Standard Test. Offline standard tests shall include testing procedures performed while the electrical equipment or device is disconnected from the source of supply or is connected to an external test voltage source of supply.

N 8.3.4 Category 2A — Offline Enhanced Test. Offline enhanced tests shall include certain testing procedures performed while the electrical equipment or device is disconnected from the source of supply or is connected to an external test voltage source of supply and that are not typically performed in normal electrical maintenance activities and that provide additional diagnostic information. (See A.8.3.)

N 8.4 Qualifications of Testing Personnel.

N 8.4.1 Testing personnel shall be qualified to operate the test equipment used in the type of test to be performed.

N 8.4.2 Testing personnel shall be qualified to perform the test procedure on the specific equipment to be tested.

N 8.5 Test Equipment and Tools.

N 8.5.1 The test equipment shall be maintained in satisfactory mechanical and electrical condition.

N 8.5.2 The test equipment shall be applied in accordance with the manufacturer's specifications.

N 8.5.3* Test equipment that provides measurements shall be calibrated.

N 8.5.4 Calibration information shall be readily available for all test equipment.

N 8.5.5 Test equipment calibration intervals shall be appropriate to ensure the accuracy of the test instrument with consideration for the conditions of use.

N 8.5.6 Proper tools, instruments, and other test equipment shall be used when performing maintenance activities.

N 8.6 Test Record.

N 8.6.1 A test record shall be created for all field tests of electrical equipment.

N 8.6.2 Test records shall contain the following minimum information:

- (1) Identification of the testing person and organization
- (2) Identification of the equipment under test
- (3) Nameplate or label data from the equipment under test
- (4) Environmental conditions, such as humidity and temperature, that could affect the results of the tests or calibrations
- (5) Date of the test
- (6) Indication of test performed
- (7) Indication of pass/fail criteria, where applicable
- (8) Indication of as-found and as-left test results, where applicable
- (9) Test operator's comments or recommendations, where applicable

N 8.7* Condition of Maintenance Indication. Information shall be made readily available to communicate the condition of maintenance.

N 8.7.1 Conditions of Maintenance.

N 8.7.1.1 Serviceable. Equipment that passes all tests and is electrically and mechanically sound shall be designated as serviceable.

N 8.7.1.2* Limited Service. Equipment that has problems that are not detrimental to the protective operation or design characteristics of the equipment shall be designated as limited service.

N 8.7.1.3* Non-serviceable. Equipment that has a problem that is detrimental to the proper electrical or mechanical operation of the equipment shall be designated as non-serviceable.

N Chapter 9 Maintenance Intervals

N 9.1 Scope. This chapter identifies the required frequency of maintenance for electrical equipment.

N 9.1.1* Continuous Monitoring and Predictive Techniques.

N 9.1.1.1* Continuous monitoring or predictive techniques shall be permitted to be used as a consideration when determining maintenance intervals.

N 9.1.1.2* Continuous monitoring or predictive techniques shall be based on manufacturer's recommendations or accepted industry practices.

N 9.1.2 Maintenance Frequency Modifications.

N 9.1.2.1 Once the initial frequency for inspection and tests has been established based on the intervals listed in Table 9.2.2 and the equipment condition assessment, this frequency shall be adhered to for at least two maintenance cycles unless unexpected failures occur.

N 9.1.2.1.1 For equipment that has unexpected failures, the cause of the failure shall be used to determine if the maintenance interval for the equipment needs to be reduced.

N 9.1.2.1.2* If more than two inspections are completed without requiring additional service, the equipment owner shall be permitted to resume the original inspection period.

N 9.1.2.2 If more than two inspections are completed without detecting equipment problems, the maintenance cycle shall be permitted to be extended to longer intervals than listed in Table 9.2.2.

N 9.2 Frequency of Maintenance.

N 9.2.1* The manufacturer's recommendations shall be followed for each of the maintenance scopes specified in this standard for the required intervals.

N 9.2.2* Where the manufacturer's recommendations are not provided or available and failure, breakdown, or malfunction of the equipment will present an unacceptable risk for personnel or the environment, equipment maintenance shall be performed at not greater than the intervals specified in Table 9.2.2, in accordance with the equipment condition assessment in Section 9.2, and as modified by the other parts of this chapter.

N 9.2.2.1 The intervals in Table 9.2.2 shall only be required if referenced by a specific section in another chapter.

N 9.2.2.2 The maintenance interval for electrical equipment shall be permitted to be altered based on the potential risk to personnel or facility operations due to a failure of the equipment to operate as expected.

N 9.2.2.3 Any deviations from the maintenance intervals described in Table 9.2.2 to extend the maintenance interval and the justification for the deviation shall be documented in the EMP.

N 9.3 Equipment Condition Assessment. The equipment condition shall be the highest condition category in accordance with 9.3.1, 9.3.2, and 9.3.3 as determined by the owner or their designee.

N 9.3.1 Physical Condition of Electrical Equipment. Equipment that is included in the electrical EMP shall be assessed for current equipment condition in accordance with 9.3.1.1 through 9.3.1.3.

N 9.3.1.1 Equipment Physical Condition 1 shall be assigned where all the following criteria apply:

- (1) The equipment appears in like new condition.
- (2) The enclosure is clean, free from moisture intrusion, and tight.
- (3) No unaddressed notification from the continuous monitoring system has occurred.
- (4) There are no active recommendations from predictive techniques.
- (5) Previous maintenance has been performed in accordance with the EMP.

N Table 9.2.2 Maintenance Intervals

Product	Scope of Work	Equipment Condition Assessment		
		Condition 1	Condition 2	Condition 3
All equipment	Infrared thermography	12 months	12 months	6 months
Battery ESSs	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
	Mechanical servicing		Reserved	
	Electrical testing	60 months	36 months	12 months
Busways	Visual inspection	60 months	60 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
	Special	60 months	36 months	12 months
Cable trays	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Electric vehicle power transfer systems	Visual inspection	60 months	36 months	12 months
	Mechanical inspection	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Electronic equipment			Reserved	
Fuses	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
GFCIs	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing		Reserved	
Grounding and bonding	Visual inspection	12 months	12 months	6 months
	Cleaning		Reserved	
	Lubrication		Reserved	
	Mechanical servicing		Reserved	
	Electrical testing	60 months	36 months	36 months
High-voltage substation insulators	Visual inspection	12 months	12 months	6 months
	Corona detection	12 months	6 months	4 months
	Maintenance and testing	60 months	36 months	12 months
Lighting	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Servicing	60 months	36 months	12 months

(continues)

N Table 9.2.2 *Continued*

Product	Scope of Work	Equipment Condition Assessment		
		Condition 1	Condition 2	Condition 3
Lighting control systems			Reserved	
Low-voltage ground-fault protection systems	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Medium-voltage ground-fault protection systems	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Medium-voltage power circuit breakers	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Molded-case/insulated-case/low-voltage power circuit breakers	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Motor control equipment	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Panelboards and switchboards	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical inspections	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Photovoltaic systems	Visual inspection	60 months	36 months	12 months
	Cleaning		Reserved	
	Lubrication		Reserved	
	Mechanical servicing		Reserved	
	Electrical testing	60 months	36 months	12 months
Portable electrical tools and equipment	Visual inspection	Before each use	Before each use	Before each use
	Cleaning	Before each use	Before each use	Before each use
	Lubrication	In accordance with the manufacturer's instructions	In accordance with the manufacturer's instructions	In accordance with the manufacturer's instructions
	Mechanical servicing	In accordance with the manufacturer's instructions	In accordance with the manufacturer's instructions	In accordance with the manufacturer's instructions

(continues)

Shaded text = Revisions.  = Text deletions and figure/table revisions. • = Section deletions. **N** = New material

N Table 9.2.2 *Continued*

Product	Scope of Work	Equipment Condition Assessment		
		Condition 1	Condition 2	Condition 3
	Electrical testing	3 months	3 months	3 months
Power and distribution transformers	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Power cables	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Mechanical servicing	Reserved	Reserved	
	Electrical testing	60 months	36 months	12 months
Power-factor correction capacitors	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Protective relays, electromechanical	Visual inspection	36 months	24 months	12 months
	Cleaning	36 months	24 months	12 months
	Lubrication		Reserved	
	Mechanical servicing	36 months	24 months	12 months
	Electrical testing	36 months	24 months	12 months
Protective relays, solid state and microprocessor	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Public pools, fountains, and similar installations			Reserved	
Rotating equipment	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Stationary standby batteries	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Mechanical servicing		Reserved	
	Electrical testing	60 months	36 months	12 months
Substations	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
	Special	60 months	36 months	12 months
	Mechanical checks	60 months	36 months	12 months

(continues)

N Table 9.2.2 *Continued*

Product	Scope of Work	Equipment Condition Assessment		
		Condition 1	Condition 2	Condition 3
Switches	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Switchgear	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Uninterruptible power supplies	Special	60 months	36 months	12 months
	Visual inspection	6 months	3 months	1 month
	Cleaning	12 months	6 months	3 months
	Lubrication		Reserved	
	Mechanical servicing	12 months	6 months	3 months
Wind power electric systems	Electrical testing	12 months	6 months	3 months
	Special procedures	24 months	24 months	24 months
	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	
Wiring devices	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
	Visual inspection	12 months	3 months	1 month
	Cleaning	60 months	36 months	12 months
	Lubrication		Reserved	

N 9.3.1.2 Equipment Physical Condition 2 shall be assigned where all of 9.3.1.1 apply, and where any of the following criteria apply:

- (1) Maintenance results deviate from past results or have indicated more frequent maintenance in accordance with manufacturer's published data.
- (2) The previous maintenance cycle has revealed issues requiring the repair or replacement of major equipment components.
- (3) There have been notifications from the continuous monitoring system since the prior assessment.
- (4) There are active recommendations from predictive techniques.

N 9.3.1.3 Equipment Physical Condition 3 shall be assigned where changes in operation are noted or where any of the following criteria applies:

- (1) The equipment has missed the last two successive maintenance cycles in accordance with the EMP.

- (2) The previous two maintenance cycles have revealed issues requiring the repair or replacement of major equipment components.
- (3) There is an active or unaddressed notification from the continuous monitoring system.
- (4) There are urgent actions identified from predictive techniques.

N 9.3.1.4 Nonserviceable Equipment.

N 9.3.1.4.1 Equipment that poses an imminent risk of injury or negative health effects to personnel shall be designated as nonserviceable in accordance with 8.7.1.3.

N 9.3.1.4.2 Access to nonserviceable equipment by unqualified persons shall be restricted.

N 9.3.1.5 Nonconforming Equipment. Equipment exhibiting characteristics that do not conform to any of the above conditions shall be identified as requiring corrective measures before returning it to a normal operating condition.

N 9.3.2* Criticality Condition of Equipment.

N 9.3.2.1* Criticality Condition 1 or Criticality Condition 2 shall be permitted to be assigned where the failure of the equipment or system will not endanger personnel.

N 9.3.2.2 Criticality Condition 3 shall be assigned where the failure of the equipment or system will endanger personnel.

N 9.3.3 Operating Environment Condition of Equipment.

N 9.3.3.1 Operating Environment Condition 1 or Operating Environment Condition 2 shall be permitted to be assigned where the equipment is used in an operating environment for which it is rated.

N 9.3.3.2 Operating Environment Condition 3 shall be assigned where the equipment is used in an environment with harsh chemicals, contaminants, or extreme operating conditions for which it is not specifically rated or evaluated.

N Chapter 10 Hazardous (Classified) Location Electrical Equipment

N 10.1* General. Electrical equipment designed for use in hazardous (classified) locations shall be maintained through regular inspections, testing, and servicing, as recommended by the manufacturer.

N 10.1.1 Documentation shall be readily available to identify the classification, group, temperature code specification, and extent of the classified area.

N 10.1.2* Repairs and maintenance, including access to and removal of components, shall not be performed inside the hazardous (classified) area unless a documented risk assessment to determine the risk of igniting an explosive atmosphere is conducted by a qualified person.

N 10.1.3 Electrical maintenance documentation shall identify where the maintenance is to be performed and what precautions are necessary.

N 10.1.4 A thorough inspection shall be performed after any maintenance work to ensure the equipment is restored to a safe operational condition.

N 10.2 Maintenance Personnel for Hazardous (Classified) Locations.

N 10.2.1 Maintenance shall be performed only by qualified persons who are trained in safe maintenance practices and the special considerations necessary to maintain electrical equipment for use in the specific class of hazardous (classified) locations.

N 10.2.2* Qualified persons shall be trained to evaluate and eliminate ignition sources and to identify the need for special tools, procedures, equipment, tests, and protective clothing.

N 10.3 Elimination of Hazardous Atmospheres. For maintenance involving permanent electrical installations, the following procedures shall be followed:

- (1) Hazardous vapors, dust, or fibers/flyings shall be removed from the area.
- (2) Enclosed or trapped hazardous vapors shall be cleared.
- (3) Atmosphere shall be tested to confirm it is within safe limits for the required maintenance.

N 10.4 Elimination of Ignition Sources.

N 10.4.1* An electrically safe work condition shall be established, and all other ignition sources abated before maintenance is performed.

N 10.4.2 Before opening any enclosure, time shall be allowed for parts to cool and electrical charges to dissipate, as identified in the risk assessment or manufacturer's instructions.

N 10.4.3 Bonding jumpers shall be applied as required to dissipate and prevent static electrical charges.

N 10.5 Equipment Reassembly.

N 10.5.1 Electrical equipment designed for use in hazardous (classified) locations shall be fully reassembled with original components or approved replacement components before the hazardous atmosphere is reintroduced.

N 10.5.2 Covers shall not be interchanged unless identified for the purpose.

N 10.5.2.1* Prior to reinstalling covers, they shall be checked for proper closure of mating joints and seals.

N 10.5.2.2 Mating joints or seals that do not make a proper closure shall be repaired or replaced in accordance with the manufacturer's instructions.

N 10.6 Conduit and Equipment Seals.

N 10.6.1 An approved system of conduit and equipment seals shall be maintained.

N 10.6.2* Corrective action shall be taken on any seal that is found to be damaged or missing.

N 10.7 Bolts and Screws. Where bolts or screws used to secure an electrical equipment cover require torquing to meet installation specifications, the bolts or screws shall be maintained with the torque specified by the manufacturer.

N 10.7.1 All bolts and screws shall be replaced with original components or as specified by the manufacturer.

N 10.8* Handling of Equipment, Components, and Tools. Electrical equipment used in hazardous (classified) locations shall not be subjected to damage from tools that pry, impact, or abrade components.

N 10.8.1 Where grease, paint, or dirt must be cleaned from machined joints, a nonmetallic bristle brush, an acceptable noncorrosive solvent, or other methods recommended by the manufacturer shall be used.

N 10.8.2 Prior to replacing a cover on an enclosure designed to prevent flame propagation upon an explosion, mating surfaces shall be cleaned and lubricated in accordance with the manufacturer's instructions.

N 10.9* Field Modifications. Field modifications of equipment and parts shall be limited to those changes acceptable to the manufacturer and, where required, approved by the AHJ.

N Chapter 11 Power and Distribution Transformers**N 11.1 Scope.**

N 11.1.1 This chapter identifies electrical maintenance requirements for power and distribution transformers.

N 11.1.2 This chapter does not apply to control power and instrument transformers.

N 11.2 Frequency of Maintenance. The periodic maintenance procedures specified in Section 11.3 shall be performed in accordance with the frequencies specified in Chapter 9, unless otherwise specified in Table 11.2.

N 11.3 Periodic Maintenance Procedures.

N 11.3.1 Visual Inspections. Transformers shall be visually inspected in accordance with Table 11.3.1.

N 11.3.2 Cleaning.

N 11.3.2.1 Transformers shall be cleaned to remove buildup of accumulated dirt and debris.

N 11.3.2.2 Transformer bushings and any accessible insulators and conductors shall be wiped clean to remove surface buildup of contaminants.

N 11.3.3 Lubrication. (Reserved)

N 11.3.4 Mechanical Servicing. Transformers shall be mechanically serviced in accordance with Table 11.3.4.

N 11.3.5* Electrical Testing. Transformers shall be electrically tested in accordance with Table 11.3.5.

N 11.3.6 Special. (Reserved)

N Table 11.2 Frequency of Maintenance

Scope of Work	Equipment Condition Assessment			Notes
	Condition 1	Condition 2	Condition 3	
Sample insulating fluid and tests	12 months	12 months	6 months	See 11.3.5.

N Table 11.3.1 Transformer Visual Inspections

No.	Task	Dry Type, Air-Cooled		Liquid-Filled Test Type*	Notes
		Small, Windings, ≤600 Volts, ≤167 kVA 1-ph, ≤500 kVA 3-ph Test Type*	Large, Windings, >600 Volts, >167 kVA 1-ph, >500 kVA 3-ph Test Type*		
1	Bolted connections	2	2	2	
2	Cooling devices	2	2	2	
3	Liquid level gauge(s) and alarm(s)	NA	NA	2	
4	Neutral grounding impedance devices	2	2	2	
5	Nitrogen bottle pressure system	NA	NA	2	
6	Pressure relief device(s)	NA	NA	2	
7	Sudden pressure relay(s)	NA	NA	2	
8	Tank over/under pressure gauge and alarms	NA	NA	2	
9	Transformer enclosure	1 or 2	1 or 2	1 or 2	Ensure ventilation and equipment enclosure integrity has not been compromised.

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 11.3.4 Transformer Mechanical Servicing

No.	Task	Test Type*			Notes
		Dry Type, Air-Cooled		Liquid-Filled	
		Small, Windings ≤600 V ≤167 kVA 1-ph, ≤500 kVA 3-ph	Large, Windings >600 V >167 kVA 1-ph, >500 kVA 3-ph		
1	Bolted connection	2	2	2	
1A	Verify tightness of accessible bolted electrical connections	2	2	2	
1B	Verify as-left tap connections are as specified	2	2	2	
2	Inspect anchorage, alignment, and grounding	2	2	2	
3	Cooling devices	2	2	2	
4	Transformer enclosures, ventilation filters, and screens inspected and replaced or cleaned, as needed	2	2	NA	
5	Control cabinets connections and cleaning	2	2	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 11.3.5 Transformer Electrical Tests

No.	Task	Dry Type, Air-Cooled			Liquid-Filled Test Type*	Notes
		Small, Windings, ≤600 Volts, ≤167 kVA 1-ph, ≤500 kVA 3-ph	Large, Windings, >600 Volts, >167 kVA 1-ph, >500 kVA 3-ph			
		Test Type*	Test Type*			
1	Core insulation resistance	NA	2A		2A	
2	Excitation current on each phase	NA	2		2	
3	Insulation power factor	NA	2		2	
4	Insulation power factor tip-up	NA	2A		NA	
5	Main insulation resistance	2	2		2	
6	Neutral grounding impedance devices	NA	2		2	
7	Online partial discharge on MV/HV windings	NA	1A		1A	
8	Insulation power factor on each bushing	NA	NA		2†	
9	Sweep frequency response analysis	NA	NA		2A	
10	Turns ratio on all load tap changer (LTC) taps	NA	NA		2A	
11	Turns ratio on all no-load tap changer (NLTC) taps	2A	2A		2A	
12	Turns ratio on designated tap	2	2		2	
13	Winding resistance at designated tap	2A	2A		2	
14	Bolted connection resistance	2	2		2	
15	Applied voltage test	NA	2A		NA	
16	Sample insulating fluid and test for:					
	Dielectric breakdown	NA	NA		1 or 2	
	Acid neutralization number	NA	NA		1 or 2	
	Specific gravity	NA	NA		1 or 2	
	Interfacial tension	NA	NA		1 or 2	
	Color	NA	NA		1 or 2	
	Visual condition	NA	NA		1 or 2	
	Water content	NA	NA		1 or 2	
	Power factor	NA	NA		1 or 2	
	Dissolved gas analysis	NA	NA		1, 1A or 2, 2A	
	Furan analysis	NA	NA		1, 1A or 2, 2A	
17	Sweep frequency response analysis	NA	NA		2A	
18	Percent oxygen in insulating blanket	NA	NA		2A	
19	Testing of transformer alarms, including temperature, liquid level, nitrogen bottle pressure, tank over/under pressure, sudden pressure	NA	NA		2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

†Transformers applied at voltages greater than 1000 volts.

N Chapter 12 Substations and Switchgear

N 12.1 Scope.

N 12.1.1 This chapter identifies electrical maintenance requirements for substations, switchgear, and surrounding areas, whether fenced or in rooms.

N 12.1.2* This chapter does not address requirements of individual components of substations and switchgear that are addressed in the chapters for those components.

N 12.2 Frequency of Maintenance. The periodic maintenance procedures specified in Section 12.3 shall be performed in accordance with the frequencies specified in Chapter 9, unless otherwise specified in this chapter.

N 12.3 Periodic Maintenance Procedures.

N 12.3.1* Visual Inspection. Substations and switchgear shall be visually inspected in accordance with Table 12.3.1.

N 12.3.2 Cleaning. Electrical equipment surfaces, enclosures, insulating materials, and surrounding areas shall be kept clean to prevent a buildup of contaminants that negatively affect performance, reduce life expectancy, or create a safety hazard.

N 12.3.3 Lubrication. Terminating devices, mechanical parts, or operating parts that open, close, insert, and trip a circuit

breaker, switch, or protective device shall be lubricated as required per the manufacturer's instruction manual.

N 12.3.4* Mechanical Servicing. Substation and switchgear shall be mechanically serviced in accordance with Table 12.3.4.

N 12.3.5* Electrical Testing. Substations and switchgear shall be electrically tested in accordance with Table 12.3.5.

N 12.3.6 Special.

N 12.3.6.1 Miscellaneous Equipment.

N 12.3.6.1.1* The availability and condition of required dedicated maintenance or operational tools and other test equipment shall be inspected.

N 12.3.6.1.2 If found to be defective, the dedicated maintenance or operational tools or other test equipment shall be taken out of service, replaced, or repaired, according to the manufacturer's specifications.

N 12.3.6.2 Auxiliary Apparatus. Area lighting, exit and emergency lighting, room HVAC or ventilation systems, and other auxiliary apparatus shall be checked for proper operation.

N Table 12.3.1 Substation and Switchgear Visual Inspections

No.	Task	1000 Volts or Below Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Inspect external physical condition	1	1	This includes condition and integrity of applied labels.
2	Inspect anchorage and grounding	1	1	Document if anchorage is not appropriate in accordance with current seismic requirements so improvements can be considered.
3	Ensure maintenance devices and tools are available for equipment servicing	1	1	
4	Verify circuit breakers, fuses, protective relays, and other type of overload elements are the right sizes and types and correspond to the drawings and the power system studies	1 or 2	1 or 2	Verify against plans, drawings, and pertinent records, as well as against evidence of current load levels. Some devices might be able to be checked while panel doors are closed.
5	For connected communicating addressable devices, verify the device addresses are set in accordance with documentation	1 or 2	1 or 2	Confirm addressing or correct device association where protective devices or the human-machine interface (HMI) are connected to multiple devices via a communication network.
6	Verify instrument transformer ratios are correct as installed	2A	2A	
7	Inspect insulators for damage or contaminated surfaces	2	2	
8	Verify air filters or screens are clean and in place	1 or 2	1 or 2	
9	Check all ventilation openings for obstructions and correct operation of any flap or automatic cover intended to assist in arc resistant ratings	2	2	
10	Inspect arc resistant equipment to ensure all doors are secured and in place	1 or 2	1 or 2	
11	Verify switch phase barriers are in place and in good condition	2	2	
12	For individual components, refer to the appropriate chapter(s) of this standard	NA	NA	
13	Visually inspect environmental controls, where provided	1 or 2	1 or 2	Includes, but is not limited to, fans, heaters, thermostats and humidity control equipment and settings.

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 12.3.4 Substation and Switchgear Mechanical Servicing

No.	Task	1000 Volts or Below Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Check circuit breakers and switches — mechanical operation	2	2	See manufacturer's instructions, Chapter 15, and Chapter 17.
2	Check bolted connection resistance	2	2	See Chapter 7.
3	Verify lubrication on moving current-carrying parts and sliding surfaces	2	2	See manufacturer's instructions.
4	Verify mechanical interlock systems for correct sequencing	2	2	
5	Verify mechanical systems for correct sequencing, including shutters, racking mechanisms, and similar	2	2	
6	Verify mechanical indicating devices are functional	2	2	
7	Verify filters or screens are clean and in place	1 or 2	1 or 2	Include filters and screens in the room related to the substation or switchgear.
8	Verify fuse holders provide mechanical support and contact integrity	2	2	
9	For individual components, refer to the appropriate chapter(s) of this standard	NA	NA	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 12.3.5 Substation and Switchgear Electrical Tests

No.	Task	1000 Volts or Below Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Inspect electrical connections for high resistance	2	2	See Section 7.2.
2	Perform ground resistance test	2	2	See 20.3.5. Perform point-to-point test to determine the resistance between the main grounding system and substation/switchgear frames, system neutral, or derived neutral points. Perform fall-of-potential or alternative test on the grounding electrode system.
3	Measure insulation resistance	2	2	
4	Measure insulation resistance of control wiring	2A	2A	
5	Test protective devices and systems	2	2	For surge protective devices, surge arresters, and arc-energy reduction systems, see the manufacturer's instructions.
6	Perform system operational tests	2	2	Include emergency or standby sources of power systems to ensure they are available when needed, automatic throw-overs, paralleling controls, interlock systems, or any other operational or maintenance-related control that might be installed.
7	Perform dielectric withstand test	NA	2A	
8	Perform online partial discharge (PD) survey	NA	1A	
9	Where environmental controls are provided, check for correct operating condition	1 or 2	1 or 2	Includes, but is not limited to, fans, heaters, thermostats and humidity control equipment and settings.
10	Test control power transformers, instrument transformers, and metering to ensure correct operation	1 or 2	1 or 2	
11	Verify operation of communications systems	1 or 2	1 or 2	
12	For individual components, refer to the appropriate chapter(s) of this standard	NA	NA	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Chapter 13 Panelboards and Switchboards

N 13.1 Scope.

N 13.1.1* This chapter identifies electrical maintenance requirements for panelboards and switchboards rated 1000 V or below.

N 13.1.2* This chapter does not address requirements of individual components of panelboards and switchboards that are addressed in the chapters for those components.

N 13.2 Frequency of Maintenance. The periodic maintenance procedures specified in Section 13.3 shall be performed in accordance with the frequencies specified in Chapter 9, unless otherwise specified in this chapter.

N 13.3 Periodic Maintenance Procedures.

N 13.3.1 Visual Inspection. Panelboards and switchboards shall be visually inspected in accordance with Table 13.3.1.

N 13.3.2 Cleaning. Bus insulation, cable insulation, terminals or terminations, electrical equipment surfaces, enclosures, and insulating materials shall be kept in a clean and contaminant-free state.

N 13.3.3 Lubrication. Terminating devices, mechanical parts, and operating parts that exist to open, close, insert, and trip a circuit breaker, switch, or protective device shall be lubricated as required in accordance with the manufacturer's instructions.

N 13.3.4 Mechanical Servicing. Panelboards and switchboards shall be mechanically serviced in accordance with Table 13.3.4.

N 13.3.5 Electrical Testing. Panelboards and switchboards shall be electrically tested in accordance with Table 13.3.5.

N 13.3.6 Special. (Reserved)

N Table 13.3.1 Panelboard and Switchboard Visual Inspections

No.	Task	Test Type*	Notes
1	Inspect external physical condition	1	This includes condition and integrity of applied labels.
2	Inspect anchorage and grounding	1	
3	Verify circuit breakers, fuses, and overload elements are the right sizes and types and correspond to the drawings and power system studies	2	
4	For connected communicating addressable devices, verify the device addresses are set in accordance with documentation	2	Confirm addressing or correct device association where protective devices or the human machine interface (HMI) are connected to multiple devices via a communication network.
5	Verify instrument transformer ratios are correct	2	
6	Inspect insulators for damage or contaminated surfaces	2	
7	Verify filters are clean and in place	2	
8	Ensure maintenance devices and tools are available for equipment servicing	1	
9	Verify phase barriers are in place	2	
10	Visually inspect environmental controls, where provided	1 or 2	Includes, but is not limited to, fans, heaters, thermostats and humidity control equipment and settings.
11	For individual components, refer to the appropriate chapter(s) of this standard	NA	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

Shaded text = Revisions.  = Text deletions and figure/table revisions. • = Section deletions. **N** = New material



N Table 13.3.4 Panelboard and Switchboard Mechanical Servicing

No.	Task	Test Type*	Notes
1	Inspect mechanical condition	2	
2	Ensure maintenance devices and tools are available for equipment servicing	1 or 2	
3	Inspect anchorage and grounding	2	
4	Mechanically operate circuit breakers and switches	2	
5	Inspect bolted connection integrity	2	See Chapter 7.
6	Verify lubrication on moving current-carrying parts and sliding surfaces	2	See the manufacturer's instructions.
7	Verify mechanical interlock systems for correct sequencing	2	
8	Verify mechanical indicating devices are functional	2	
9	Verify filters are clean and in place	2	
10	Verify fuse holders provide mechanical support and contact integrity	2	
11	For individual components, refer to the appropriate chapter(s) of this standard	NA	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

Table 13.3.5 Panelboard and Switchboard Electrical Testing

No.	Task	Test Type*	Notes
1	Check electrical hardware connections	NA	See Chapter 7.
2	Measure insulation resistance of the main bus	2	
3	Measure insulation resistance of control wiring	2A	
4	Test protective devices and systems	2	For surge protective devices, surge arresters, and arc-fault energy reduction systems, see the manufacturer's instructions.
5	Perform system operational tests	1 or 2	Includes emergency or standby power systems.
6	Test control power transformers, instrument transformers, and metering to ensure correct operation	2	
7	For individual components, refer to the appropriate chapter(s) of this standard	NA	
8	Where environmental controls are provided, check for correct operating condition	1 or 2	Includes, but is not limited to, fans, heaters, thermostats, and humidity control equipment and settings.

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

Chapter 14 Busways

14.1* Scope. This chapter identifies electrical maintenance requirements for busways and associated fittings.

14.2 Frequency of Maintenance. The periodic maintenance procedures in Section 14.3 shall be performed in accordance with the frequencies in Chapter 9, unless otherwise specified in this chapter.

14.3 Periodic Maintenance Procedures.

14.3.1* Visual Inspection. Busways shall be visually inspected in accordance with Table 14.3.1.

14.3.2* Cleaning.

14.3.2.1* Accumulations of dust, dirt, and debris shall be removed from busways using a brush, vacuum cleaner, or clean, lint-free rags.

14.3.2.2 Compressed air shall not be used to remove dust, dirt, or debris from busways or associated fittings.

14.3.3* Lubrication.

14.3.3.1 Operating mechanisms and interlocks on plug-in units shall be lubricated in accordance with the manufacturer's instructions.

14.3.3.2 Where no manufacturer's instructions are available, non-current-carrying mechanisms and interlocks shall be lubricated with a clean, light grease.

14.3.3.3 Excess lubrication shall be wiped off to avoid accumulation of foreign material.

14.3.3.4 Where plug-in units are relocated, electrical plug-in connections on plug-in units shall be lubricated in accordance with the manufacturer's instructions with a conductive lubricant labeled for use on electrical power connections.

14.3.4 Mechanical Servicing. Busways shall be mechanically serviced in accordance with Table 14.3.4.

14.3.5* Electrical Testing. Busways shall be electrically tested in accordance with Table 14.3.5.

14.3.6 Special. (Reserved)

N Table 14.3.1 Busway Visual Inspections

No.	Task	Busways Rated 600 Volts or Less Test Type*	Busways Rated Over 600 Volts Test Type*	Notes
1	Visually inspect the physical condition of the busway and associated fittings	1	1	Look for evidence of moisture contamination, corrosion, and excessive buildup of dust, dirt, or debris.
2	Visually inspect anchorage, hangers, and alignment of busway system	1	1	Look for loose connections and twisting or bending of lifted supports.
3	Visually inspect all areas near electrical joints, terminations, and connections	2	2	Visually check connections to be certain that they are clean and secure and show no signs of overheating or discoloration.
4	Examine outdoor busway to ensure that weepholes are not obstructed and that the joint shield is installed correctly	1	1	
5	Inspect ventilation openings on busway and associated fittings	1	1	
6	Look for signs of deterioration of visible seals and gaskets	1	1	Outdoor and drip-resistant busways can contain seals and gaskets.
7	For individual components, refer to the appropriate chapter(s) of this standard	NA	NA	

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 14.3.4 Busway Mechanical Servicing

No.	Task	Busways Rated 600 Volts or Less Test Type*	Busways Rated Over 600 Volts Test Type*	Notes
1	Adjust or repair anchorage or hangers to ensure support of the busway	2	2	
2	Exercise plug-in unit operating mechanisms and external operators to confirm they operate to their full ON and OFF positions	2	NA	
3	Confirm operation of mechanical interlocks and locking means of plug-in units	2	NA	
4	Clean ventilation openings and weep holes	2	2	
5	Inspect forced-air cooling system	NA	2	Verify operation of forced-air cooling that could be included in metal enclosed bus systems.
6	Inspect for loose, open, or missing covers or doors on busways and associated fittings	2	2	Inspect all plug-in openings, plug-in units, and joints between busway sections. Some covers are not designed to be removed for inspection.
7	For individual components, refer to the appropriate chapter(s) of this standard	NA	NA	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 14.3.5 Busway Electrical Tests

No.	Task	Busways Rated 600 Volts or Less Test Type*	Busways Rated Over 600 Volts Test Type*	Notes
1	Perform bus resistance tests	1 or 2	1 or 2	See Chapter 7.
2	Perform insulation resistance tests	2	2	See A.14.3.5 for additional information.
3	Perform a dielectric withstand voltage test	NA	2	See A.14.3.5 for additional information.
4	Where environmental controls are provided, check for correct operating condition	1 or 2	1 or 2	Includes, but is not limited to, fans, heaters, thermostats, and humidity control equipment and settings.
5	Perform insulation power-factor or dissipation-factor tests	NA	2A	
6	Perform online partial-discharge survey	NA	1A	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Chapter 15 Circuit Breakers, Low- and Medium-Voltage

N 15.1 Scope.

N 15.1.1 This chapter identifies electrical maintenance requirements for the following circuit breakers and their enclosures:

- (1) Molded-case circuit breakers (MCCBs) rated less than or equal to 1000 V ac
- (2) Insulated-case circuit breakers (ICCBs) rated less than or equal to 1000 V ac
- (3) Low-voltage power circuit breakers (LVPCBs) rated less than or equal to 1000 V ac
- (4) Medium-voltage power circuit breakers (MVPCBs) rated greater than 1000 V ac to less than or equal to 69 kV ac

N 15.2 Frequency of Maintenance. The periodic maintenance procedures in Section 15.3 and Section 15.4 shall be

performed in accordance with the frequencies in Chapter 9, unless otherwise specified in this chapter.

N 15.3 Periodic Maintenance Procedures for Low-Voltage Power Circuit (LVPCB), Molded Case Circuit Breaker (MCCB), and Insulated Case Circuit Breakers (ICCB).

N 15.3.1 Visual Inspections. A visual inspection shall be conducted in accordance with Table 15.3.1.

N 15.3.2 Cleaning.

N 15.3.2.1 Electrical equipment surfaces, enclosures, and insulating materials shall be kept in a clean and contaminant-free state.

N Table 15.3.1 MCCB, ICCB, and LVPCB Visual Inspections

No.	Task	MCCB Test Type*	ICCB Test Type*	LVPCB Test Type*	Notes
1	Verify ratings for proper system application.	1 or 2	1 or 2	1 or 2	
2	Inspect insulating materials and frame for evidence of physical damage, cracks from stresses of operation, or contamination.	2	2	2	
3	Inspect wiring, bus, cables, and connections for damaged insulation, broken leads, tightness of connections, proper crimping, and overall general condition, including corrosion.	2	2	2	
4	Inspect visible current-carrying parts and control devices if applicable for signs of overheating or deterioration.	2	2	2	
5	Inspect arc chutes for cracks or excessive erosion if applicable.	NA	2	2	
6	Check for cracks or lack of visual indication for all associated indicating status devices.	1 or 2	1 or 2	1 or 2	
7	Check all markings on the circuit breaker are legible.	1 or 2	1 or 2	1 or 2	
8	Inspect operating mechanism.	NA	2	2	
9	Check main contact over travel and arcing contact engagement.	NA	2	2	
10	Check condition of main and arcing contacts.	NA	2	2	
11	Check insulating links/push rods and interphase barriers for cracks and defects.	NA	2	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: 1 = online standard test, 1A = online enhanced test, 2 = offline standard test, 2A = offline enhanced test.

N 15.3.2.2 If contamination such as dust, dirt, soot, grease, or moisture is found, cleaning shall be performed in accordance with Table 15.3.2.2.

N 15.3.3 Lubrication. Moving and sliding surfaces shall be lubricated in accordance with Table 15.3.3.

N 15.3.4 Mechanical Servicing. Circuit breakers shall be mechanically serviced in accordance with Table 15.3.4.

N 15.3.5* Electrical Testing. Circuit breakers shall be electrically tested in accordance with Table 15.3.5.

N 15.3.6 Special. (Reserved)

N 15.4 Periodic Maintenance Procedures for Medium-Voltage Power Circuit Breakers. Medium-voltage power circuit breakers shall be maintained in accordance with this section.

N 15.4.1 Circuit breakers shall be visually inspected in accordance with Table 15.4.1.

N 15.4.2 Cleaning. Electrical equipment surfaces, enclosures, and insulating materials shall be kept in a clean and contaminant-free state in accordance with Table 15.4.2.

N 15.4.3 Lubrication. Moving and sliding surfaces shall be lubricated in accordance with Table 15.4.3.

N 15.4.4 Mechanical Servicing. Circuit breakers shall be mechanically serviced in accordance with Table 15.4.4.

N 15.4.5 Electrical Testing. Circuit breakers shall be electrically tested in accordance with Table 15.4.5.

N 15.4.6 Special. (Reserved)

N Table 15.3.2.2 MCCB, ICCB, and LVPCB Cleaning

No.	Task	MCCB Test Type*	ICCB Test Type*	LVPCB Test Type*	Notes
1	Clean insulating surfaces of the circuit breaker using a lint-free dry cloth, brush, or vacuum cleaner (avoid blowing material into the circuit breaker or into surrounding equipment)	2	2	2	
2	Clean contact surfaces in accordance with the manufacturer's instructions	NA	2	2	
3	Clean circuit breaker interior frame	NA	2	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.3.3 MCCB, ICCB, and LVPCB Lubrication

No.	Task	MCCB Test Type*	ICCB Test Type*	LVPCB Test Type*	Notes
1	Apply a thin coating of conductive lubricant to exposed contacts as specified by the manufacturer	NA	2	2	
2	Apply nonconductive lubricant as needed to mechanism parts as specified by the manufacturer	NA	2	2	
3	Apply conductive lubricant to pivot points, as well as moving and sliding surfaces as specified by the manufacturer	NA	2	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.3.4 MCCB, ICCB, and LVPCB Mechanical Servicing

No.	Task	MCCB Test Type*	ICCB Test Type*	LVPCB Test Type*	Notes
1	Check all accessible electrical hardware connections for correct torque	2	2	2	See Chapter 7.
2	Operate the circuit breaker three times	2	2	2	
3	Verify operation and alignment of mechanical safety interlocks, where applicable	2	2	2	
4	Verify correct operation of shutter assemblies on draw-out circuit breakers	2	2	2	
5	Measure and record trip bar force	NA	2A	2A	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.3.5 MCCB, ICCB, and LVPCB Electrical Tests

No.	Task	MCCB [†] 250 Amperes and Less Frame Test Type*	MCCB [†] Over 250 Amperes Frame Test Type*	ICCB Test Type*	LVPCB Test Type*	Notes
1	Perform infrared thermography	1	1	1	1	
2	Measure contact resistance of each switching pole	2A	2	2	2	
3	Perform insulation-resistance tests, phase-to-phase and phase-to-ground with circuit breaker closed and across each open pole	2A	2	2	2	
4	Operate circuit breaker auxiliary and control devices such as local and remote-control switches, shunt trips coils, close coils, motors, auxiliary switches, and under-voltage coils	2	2	2	2	
5	Verify the calibration of all functions of the trip unit by means of the manufacturer's specified test set for circuit breakers equipped with electronic trip units	2A	2	2	2	
6	Perform inverse time trip test at 300% of rated continuous current of thermal magnetic circuit breakers	2A	2	NA	NA	
7	Perform inverse time trip test at 300% of rated continuous current of electronic trip circuit breakers	2A	2A	2A	2A	
8	Perform the instantaneous overcurrent trip test for thermal-magnetic circuit breakers by "run-up" or "pulse" method	2A	2	NA	2	
9	Perform the instantaneous overcurrent trip test for electronic trip breakers by "run-up" or "pulse" method	2A	2A	2A	2A	
10	Perform rated hold-in test	2A	2A	2A	2A	
11	Test current-limiter resistance	2	2	2	2	
12	Check status of rating plug battery	2	2	2	2	
13	Perform millivolt drop test	2A	2A	2A	2A	
14	Test arc reduction technology in accordance with the manufacturer's instructions	2	2	2	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

†The rating of adjustable-trip circuit breakers shall be the maximum setting possible.

N Table 15.4.1 Medium-Voltage Power Circuit Breakers Visual Inspections

No.	Task	Air Magnetic Circuit Breakers Test Type*	Vacuum Circuit Breakers Test Type*	Gas Insulated Circuit Breakers Test Type*	Oil Circuit Breakers Test Type*	Notes
1	Verify ratings for proper system application	1 or 2	1 or 2	1 or 2	1 or 2	
2	Inspect insulating materials and frame for evidence of physical damage, cracks from stresses of operation, or contamination	2	2	2	2	
3	Inspect wiring, bus, cables, and connections for damaged insulation, broken leads, tightness of connections, proper crimping, and overall general condition including corrosion	2	2	2	2	
4	Inspect visible current-carrying parts and control devices, if applicable, for signs of overheating or deterioration	2	2	2	2	
5	Inspect each arc chute for cracks or excessive erosion	2	NA	NA	NA	
6	Inspect ground contact, secondary disconnect, close and trip interlocks, levering latch, mechanism-operated contact (MOC), and truck-operated contact (TOC) switches, and all other interlocks	2	2	2	2	
7	Check all markings on the circuit breaker are legible	1 or 2	1 or 2	1 or 2	1 or 2	
8	Inspect contact erosion indicator mark on vacuum interrupter moving stem	NA	2	NA	NA	Some manufacturers have visual inspections to determine contact erosion.
9	Inspect contact	NA	2	NA	NA	Some manufacturers have visual inspections to determine contact wipe.
10	Verify correct oil level	NA	NA	NA	2	
11	Check for oil leaks	NA	NA	NA	2	
12	Visually inspect bushings for cracks, chips, loss of porcelain, evidence of corona damage, or other physical damage	2	2	2	2	
13	Check for low gas pressure	NA	NA	2A	NA	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.4.2 Medium-Voltage Power Circuit Breakers Cleaning

No.	Task	Air Magnetic Circuit Breakers Test Type*	Vacuum Circuit Breakers Test Type*	Gas Insulated Circuit Breakers Test Type*	Oil Circuit Breakers Test Type*	Notes
1	Clean insulating surfaces of the circuit breaker using a lint-free dry cloth, brush, or vacuum cleaner (avoid blowing material into the circuit breaker or into surrounding equipment)	2	2	NA	NA	For vacuum circuit breakers, follow the manufacturer's instructions to avoid shock due to inherent capacitance from the technology used in the circuit breaker.
2	Clean contact surfaces	2	NA	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.4.3 Medium-Voltage Power Circuit Breakers Lubrication

No.	Task	Air Magnetic Circuit Breakers Test Type*	Vacuum Circuit Breakers Test Type*	Gas Insulated Circuit Breakers Test Type*	Oil Circuit Breakers Test Type*	Notes
1	Apply a thin coating of conductive lubricant to exposed contacts as specified by the manufacturer	2	2	2	2	
2	Apply nonconductive lubricant as needed to mechanism parts as specified by the manufacturer	2	2	2	2	
3	Apply conductive lubricant to pivot points, as well as moving and sliding surfaces, as specified by the manufacturer	2	2	2	2	

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.4.4 Medium-Voltage Power Circuit Breakers Mechanical Servicing

No.	Task	Air Magnetic Circuit Breakers Test Type*	Vacuum Circuit Breakers Test Type*	Gas Insulated Circuit Breakers Test Type*	Oil Circuit Breakers Test Type*	Notes
1	Check all accessible electrical hardware connections for proper torque	2	2	2	2	See Chapter 7.
2	Replace any barriers and parts that have been removed for maintenance	2	2	2	2	
3	Close and open the circuit breaker	2	2	2	2	
4	Verify operation and alignment of mechanical safety interlocks, where applicable	2	2	2	2	
5	Verify the proper operation of all circuit breaker/cell accessories, shutters, auxiliary switches, cell MOC and TOC switches, and key interlocks	2	2	2	2	
6	Verify proper operation of all cell status indicators	2	2	2	2	
7	Charge closing spring and close manually	2	2	2	2	
8	Measure and record trip bar force	2A	2A	2A	2A	
9	Perform gas leakage detection	NA	NA	2	NA	
10	Inspect pneumatic and hydraulic fittings and connections for leaks	2	2	2	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 15.4.5 Medium-Voltage Power Circuit Breakers Electrical Tests

No.	Task	Air Magnetic Circuit Breaker Test Type*	Vacuum Circuit Breaker Test Type*	Gas Insulated Circuit Breaker Test Type*	Oil Insulated Circuit Breaker Test Type*	Notes
1	Inspect electrical connections for high resistance	1 or 2	1 or 2	1 or 2	1 or 2	See Section 7.2.
2	Measure contact resistance of each switching pole	2	2	2	2	
3	Perform insulation-resistance tests, phase-to-phase and phase-to-ground with circuit breaker closed and across each open pole	2	2	2	2	
4	Verify control power for close and trip functions	2	2	2	2	
5	Perform trip and close tests with control switch	2	2	2	2	
6	Verify operating mechanism charge, anti-pump, and trip-free functions	2	2	2	2	
7	Perform vacuum integrity test by ac overpotential across each vacuum bottle	NA	2	NA	NA	
8	Verify proper operation of space heaters, if equipped	2	2	2	2	
9	Perform an ac overpotential test one pole at a time with the other poles and structure grounded	2A	2A	2A	2A	
10	Perform an ac overpotential test on control wiring	2A	2A	2A	2A	WARNING: Do not perform this test on wiring connected to solid-state components.
11	Verify blow-out coil continuity	2	NA	NA	NA	
12	Perform circuit breaker motion analysis	2A	2A	2	2	
13	Perform circuit breaker contact timing test	2	2	2	2	
14	Perform trip/close coil current signature analysis	2A	2A	2A	2A	
15	Perform pickup test on trip and/or close coil	2A	2A	2A	2A	
16	Measure power/dissipation factor	2A	NA	2A	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Chapter 16 Fuses

N 16.1 Scope. This chapter identifies electrical maintenance requirements for fuses to protect branch, feeder and service conductors.

N 16.2 Frequency of Maintenance. The periodic maintenance procedures specified in Section 16.3 shall be performed in accordance with the frequencies specified in Chapter 9, unless otherwise specified in this chapter.

N 16.3 Periodic Maintenance Procedures.

N 16.3.1* Visual Inspections. Fuses shall be visually inspected in accordance with Table 16.3.1.

N 16.3.2 Cleaning. If contamination is present, fuses shall be cleaned in accordance with Table 16.3.2.

N 16.3.3 Lubrication. (Reserved)

N 16.3.4 Mechanical Servicing. Fuses shall be mechanically serviced in accordance with Table 16.3.4.

N 16.3.5* Electrical Testing. Fuses shall be electrically tested in accordance with Table 16.3.5.

N 16.3.6 Special. (Reserved)

N Table 16.3.1 Fuse Visual Inspections

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Check for discoloration of fuse terminals and clips caused by heat	1 or 2	1 or 2	
2	Check fuse indicating device status, if applicable	1 or 2	1 or 2	
3	Confirm that fuses, in any one circuit, have the same catalog number to ensure that they have the same current rating, voltage rating, interrupting rating, time delay, and type (e.g., UL class)	1 or 2	1 or 2	
4	Confirm that all fuses match the most recent short-circuit, coordination, and arc flash studies	1 or 2	1 or 2	
5	Where current-limiting fuses are required, confirm that correct rejection-type mountings are used so that the current-limiting fuses cannot be replaced by non-current-limiting fuses	2	2	
6	Verify ratings for correct system application	1 or 2	1 or 2	
7	Inspect insulators for breaks, cracks, tracking, corona, burns, or overheating	NA	2	
8	Inspect contact surfaces for pitting or burning, alignment, and contact pressure	NA	2A	
9	Examine the fuse unit, fuse tube, and renewable element, if used, for evidence of corrosion and wear	NA	2	
10	Inspect bolts, nuts, washers, pins, and terminal connectors to ensure they are in place, in good condition, and properly installed	NA	2	
11	Inspect seals of vented expulsion type fuses	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 16.3.2 Fuse Cleaning

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Clean fuse terminals and clips that have become corroded or oxidized	2	2	
2	Clean insulators of accumulated dust and foreign matter	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 16.3.4 Fuse Mechanical Servicing

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Check fuse holder terminations for tightness	2	2	See Chapter 7.
2	Verify that each fuseholder has adequate mechanical support	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 16.3.5 Fuse Electrical Tests

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Perform infrared thermography	1	1	When equipment has infrared viewing port or is accessible while in operation.
2	Measure fuse connection resistance	2A	2	
3	Measure fuse resistance	2A	2	

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Chapter 17 Switches

N 17.1 Scope.

N 17.1.1 This chapter identifies electrical maintenance requirements for the following:

- (1) Enclosed and dead-front (safety) switches, bolted-pressure switches (BPS), high-pressure contact switches (HPC), automatic transfer switches, bypass-isolation switches, and other transfer switch equipment rated 1000 volts or less
- (2) Switches used in metal-enclosed load interrupter switchgear and automatic transfer switches, bypass-isolation switches, and other transfer switch equipment rated over 1000 volts

N 17.2 Frequency of Maintenance. The periodic maintenance procedures specified in Section 17.3 shall be performed in accordance with the frequencies specified in Chapter 9, unless otherwise specified in this chapter.

N 17.3* Periodic Maintenance Procedures.

N 17.3.1 Visual Inspection. Switches shall be visually inspected in accordance with Table 17.3.1.

N 17.3.2 Cleaning. If contamination is present, switches shall be cleaned in accordance with Table 17.3.2.

N 17.3.3* Lubrication. Switches shall be lubricated in accordance with Table 17.3.3 and the manufacturer's published instructions.

N 17.3.4 Mechanical Servicing. Switches shall be mechanically serviced in accordance with Table 17.3.4.

N 17.3.5* Electrical Testing. Switches shall be electrically tested in accordance with Table 17.3.5.

N 17.3.6 Special. (Reserved)

Shaded text = Revisions. **N** = Text deletions and figure/table revisions. • = Section deletions. **N** = New material.



N Table 17.3.1 Switch Visual Inspections

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Inspect doors and latches for fit, dents, corrosion, and missing hardware	1 or 2	1 or 2	
2	Inspect insulating materials and switch base for evidence of physical damage, cracks from stresses of operation, or contamination	2	2	
3	Inspect wiring, bus, cables, and connections for damaged insulation, broken leads, tightness of connections, crimping, and overall general condition, including corrosion	2	2	
4	Check that exposed switch contacts, both moving and stationary, are free from environmental contamination	2	NA	
5	Inspect visible current-carrying parts and control devices, if applicable, for signs of overheating or deterioration	2	2	
6	Check that fuses are secured	2	2	
7	Examine switches with exposed contacts for evidence of high short-circuit closing operation	2	NA	
8	Check the main body of the switch blades and the arcing contacts for arc erosion	2	2	Mild pitting and burning is permitted.
9	Inspect each arc chute for cracks or excessive erosion	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 17.3.2 Switch Cleaning

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Clean the switch and barriers	2	2	
2	Clean exposed switch contacts with a multi-purpose precision lubricant before lubricating	2	NA	
3	Wipe contact surfaces with a lint-free cleaning cloth	2	NA	
4	Wipe contact surfaces with a noncorrosive cleaning agent	NA	2	
5	Clean insulators	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: Type 1 = online standard test; Type 1A = online enhanced test; Type 2 = offline standard test; Type 2A = offline enhanced test.

N Table 17.3.3 Switch Lubrication

No.	Task	1000 Volts or Less Test Type*	Greater than 1000 Volts Test Type*	Notes
1	Apply a thin coating of conductive lubricant to exposed switch contacts.	2	NA	Enclosed and dead-front (safety) switches do not require lubrication.
2	Apply nonconductive lubricant as needed to mechanism parts as specified by the manufacturer.	2	NA	
3	Apply conductive lubricant to pivot points, as well as moving and sliding surfaces.	NA	2	

NA: Not applicable.

*Types specified in accordance with Section 8.3, as follows: 1 = online standard test, 1A = online enhanced test, 2 = offline standard test, 2A = offline enhanced test.