RECLAMATION

Managing Water in the West

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Volume 4-1B

Maintenance Scheduling for Electrical Equipment

U.S. Department of the Interior
Bureau of Reclamation
Denver, Colorado

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This document provides the existing tasks and frequencies for periodic maintenance of electrical equipment in Bureau of Reclamation hydroelectric power and large pumping plants. Included in this document are frequencies and references to existing PEBs and FIST.

15. SUBJECT TERMS
Electrical equipment, maintenance scheduling, maintenance, annunciators and alarms, arresters, batteries, bushings, bus work, enclosures, insulators, power cables, circuit breakers, carbon dioxide systems, coupling capacitors, overhead cranes, hoists, elevators, emergency lighting, governors, motors, relays, generators

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Acronyms and Abbreviations

AC	alternating current
AVR	automatic voltage regulator
CARMA™	Capital Asset and Resource Management Application
CO_2	carbon dioxide
DC	direct current
DGA	dissolved gas analysis
EPSS	emergency power supply systems
FIST	Facilities Instructions, Standards, and Techniques
HECP	Hazardous Energy Control Program
hipot	high potential tests
IR	infrared
kV	kilovolt
MCCB	Molded case circuit breaker
O&M	operations and maintenance
PEB	Power Equipment Bulletin
PCB	Power Circuit Breaker
PI	Polarization Index
PM	Preventive Maintenance
PMG	Permanent magnet generator
PO&M	Power Operation and Maintenance
PRO	Power Resources Office
PSS	power system stabilizer
RCM	reliability centered maintenance
RMS	Reliability Management System
RSHS	*Reclamation Safety and Health Standards*
SCADA	Supervisory Control and Data Acquisition
SSG	Speed signal generator
TSC	Technical Services Center
V	volt
WECC	Western Electricity Coordinating Council

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1. Introduction

1.1 Purpose

This Facilities Instructions, Standards, and Techniques (FIST) Volume 4-1B provides the preventive maintenance tasks and intervals of electrical equipment for periodic work orders generated by the Bureau of Reclamation's Capital Asset and Resource Management Application (CARMA) preventive maintenance modules. The intervals listed in this document are limited to the periodic intervals identified within referenced FIST volumes and Power Equipment Bulletin (PEB) documents. When the referenced FIST or PEB are revised, the tables in this FIST will also need to be revised to ensure consistency with those source documents. In the event of a conflict between this FIST and any referenced FIST or PEB, the information in the referenced FIST or PEB supersedes this FIST. It is important to note that tasks associated with commissioning or tasks associated with circuit or equipment modifications are not included in this document.

The established electrical maintenance practices associated with each task listed in this FIST can be found in the reference provided in each table. FIST volumes are available on the World Wide Web. PEBs are available only to Reclamation personnel and may be found on the intranet.

Frequencies repeated in this FIST are based on a standard time-based maintenance scheduling system. It does not address follow-up work generated by preventive maintenance activities. In the event a maintenance task or frequency is not utilized, or the adoption of other techniques is implemented, a variance or other documented approval is required. Specific details of this approval documentation and process are provided in the Directive and Standard for Technical Documents, FAC 04-14. Alternate maintenance tasks must be consciously chosen, technically sound, effectively implemented, and properly documented. The alternative to a time-based maintenance program includes a condition-based maintenance program or a reliability-centered maintenance (RCM) program that may justify longer (or shorter) time intervals.

1.2 Maintenance

Equipment and situations vary greatly, and sound engineering and management judgment must be exercised when implementing the schedules in this FIST. In some cases, warranty considerations and unique equipment configurations may require a higher maintenance frequency or a task not identified in the source FIST or PEB. Familiarity with manufacturer's maintenance recommendations is essential to ensure the necessary tasks and timeframes are implemented. Unusual

operating conditions and personal experience with the equipment may suggest a need for departure from the tasks and frequencies listed in the FIST.

Performing maintenance on electrical equipment can be hazardous. Electrical and mechanical energy can cause injury and death if not managed properly. All maintenance activity must be conducted in accordance with FIST 1-1, *Hazardous Energy Control Program* (HECP), and Reclamation Safety and Health Standards (RSHS).

1.3 Maintenance Schedules and Documentation

Complete and accurate documentation is essential to an effective maintenance program. Routine preventive electrical maintenance usually involves some form of evaluation of equipment to determine if some additional maintenance is needed to ensure the equipment can perform reliably until next evaluation. The results of the evaluation and any additional maintenance identified as a result of the routine preventive maintenance are included in the documentation of the equipment condition. **[Whether performing preventive, predictive, condition-based, or RCM, documenting equipment condition and the maintenance task is required.]**

Maintenance frequencies contained in this volume are provided for establishing a routine preventive maintenance program. This schedule states frequencies as multi-year, annually, monthly, weekly, etc.

- Weekly: Calendar week (Sunday to Saturday)
- Monthly: Calendar month (first day through the last day of the month)
- Quarterly: A calendar quarter consisting of 3 calendar months
- Semi-annually: Six calendar months
- Annually: A calendar year (January 1 through December 31)
- Multi-year: Multiple calendar years (e.g., 5-year – January 1, 2011, through December 31, 2015)

It is up to the individual office to document the tolerances associated with these stated frequencies.

Many offices use the concept of a maintenance season to describe the timeframe for performing maintenance scheduled on an annual interval. A maintenance season will be considered the period of time from October 1 of the current year through May 31 of the following year.

The maintenance schedules columns are defined as follows:

"Maintenance Task" is the "What to perform."

"Frequency" is the "When to perform."

"Reference" will provide details of the task and explain the "How to perform."

1.4 Job Plan Templates

Existing job plans created by the various facilities are available in CARMA to use as templates. Local development of complete job plans that match maintenance requirements can be expedited by using these as templates.

1.5 Power Operation and Maintenance (PO&M) Forms

PO&M forms have been updated and placed on the intranet for facility use in documenting maintenance. These forms can be filled out online and printed, or printed and completed by hand. PO&M forms are available at the Reclamation intranet site.

1.6 Reclamation Standard Practices

Reclamation has adopted a method of characterizing the importance of various tasks and schedules through the use of font style. Reclamation's regions, the Power Resources Office (PRO), and the Technical Services Center (TSC) agree that when consistent Reclamation-wide practices are needed to maintain the Federal investment, they will be designated by **[black, bold, and bracketed text]**. The regions, PRO, and TSC will collaborate to ensure that Reclamation-wide required PO&M practices are designated by bold and bracketed text. **{Red, bold, and bracketed text}** delineates mandatory power O&M requirements that Reclamation has determined must be consistent among all power facilities. A senior executive (generally the regional director) must request a waiver from requirements in red, bold, and bracketed text by submitting a waiver request. Black, bold, and bracketed text also delineates required power O&M activities. An office must request a variance from requirements in black, bold, and bracketed text through the regional chain of command by submitting a Variance Form. Information in plain text (non-bold and bracketed text) includes instructions, background information, and best practices to ensure that equipment is operated and maintained in reliable condition, and must be consulted when developing job plans. Regions, area offices, and facilities shall ensure that PO&M maintenance tasks and frequencies discussed in plain text are planned and executed to maintain power facilities in safe and reliable condition. Departure from any task or

schedule which is in plain text must be documented and contain the appropriate approvals as determined by each region. This FIST will depict the task importance that is contained in the source FIST.

NOTE: If there is a conflict in the task, frequency, or task importance between this FIST and the referenced FIST or PEB, the task, frequency, or task importance of the source supersedes this FIST.

1.7 Effect of Section Headings

Section headings or titles appearing in this document are inserted for convenience only and must not be construed as interpretations of text or a standard practice.

2. Electrical Equipment Maintenance Schedules

2.1 Alarms, Annunciators, and Monitoring

Maintenance Task	Frequency	Reference
[Operational tests of critical annunciator and alarm circuits.]	**[Operational tests of critical annunciator and alarm circuits must be performed no less than once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	PEB 43
[Real-time lockout and breaker trip coil continuity monitor and alarm.]	**[Once per shift in manned plants or once per visit in unmanned plants.]**	FIST 3-8 Table 1 FIST 3-8 Section 9.4
[Protection circuit functional test, between relay outputs and breaker input, including lockout relays.] (Section 4.2, "When functional testing relays, the requirements or mandated activities referenced in this FIST apply to relay settings that could lead to a trip or alarm [emphasis added]."	**[2 Years]**	FIST 3-8 Table 1 FIST 3-8 Section 4.2 FIST 3-8 Section 8
[Functional testing of critical	**[6 Years]**	PEB 43

Maintenance Task	Frequency	Reference
annunciator and alarm circuits.]		
[Functionally test all ICS control, protection, and alarm circuits, including all control-related, protection-related, alarm-related, and other critical inputs and outputs and all status inputs, upon commissioning and every 2 years thereafter.]	**[Upon commissioning and every 2 years thereafter.]**	FIST 3-33 Section 7.1.2.2

2.2 Arresters, Lightning, or Surge

Maintenance Task	Frequency	Reference
[Visual inspection]	**[Outdoors: semiannually**; **Indoors: annually]**	PEB 44
For PM purposes, it is recommended that a thermal analysis survey be performed annually.	Annually	FIST 4-13 Section 6.3.1
Surge arresters should be included when infrared (IR) scanning energized transformers. (Section 10, IR analysis should be conducted annually while equipment is energized and under full load, if possible.)	Annually	FIST 3-31 Section 10.2
Surge arresters: Power Factor Test Doble	3 to 6 Years	PEB 29, Power Factor Test Doble, Page 40
[Check connections]	**[6 Years]**	PEB 44
[Clean surfaces]	**[6 Years]**	PEB 44
[Electrical tests – DC insulation resistance test and power factor test.]	**[6 Years]**	PEB 44

2.3 Flooded, Wet Cell, Vented Lead Acid Batteries Including Lead Calcium and Lead Acid Batteries Used for Microwave and UHF Equipment

Maintenance Task	Frequency	Reference
[Check battery float voltage on control panel against the correct value.]	**[Plant rounds]**	FIST 3-6 Section 1.3 A FIST 3-6 Section 1.8 A PEB 55 Appendix 1
[Measure and record pilot cell float voltage with digital voltmeter.]	**[Monthly]**	FIST 3-6 Section 1.3 E PEB 55 Appendix 1
[Measure and record specific gravity readings of pilot cell.]	**[Monthly]**	FIST 3-6 Section 1.4 A PEB 55 Appendix 1
[Measure and record the temperature of the pilot cell.]	**[Monthly]**	FIST 3-6 Section 1.5 A PEB 55 Appendix 1
Record voltage using a digital voltmeter and compare battery float voltage across battery terminals with charger reading and battery bus voltmeter.	Monthly	FIST 3-6 Section 1.2 B
[Perform visual inspection. Check for: general cleanliness of the battery, mounting rack, and battery room; electrolyte leaks and cracks in cells; corrosion at terminals, connectors, racks, and cabinets; ambient temperature and make sure ventilation devices (fans and vents) are operable; all the electrolyte levels; availability and condition of all safety equipment, gloves, aprons, face shields, etc.; full gallon of labeled neutralizing solution, and operability of eyewash station or portable eyewash equipment; operation and cleanliness of body wash station; a class C fire extinguisher and check that it has been inspected and tested according to schedule; availability of insulated tools and utensils; and the	**[Monthly]**	FIST 3-6 Section 1.7 PEB 55 Appendix 1

Maintenance Task	Frequency	Reference
hydrometer for cleanliness and cracking of rubber parts.]		
[Measure and record individual cell voltages to nearest 0.01V with digital voltmeter.]	**[Quarterly]**	FIST 3-6 Section 1.3 F PEB 55 Appendix 1
[Measure and record specific gravity readings of 10 percent of the total number of cells quarterly and use different cells each quarter.]	**[Quarterly]**	FIST 3-6 Section 1.4 B PEB 55 Appendix 1
[Measure and record the temperature of 10 percent of all cells quarterly. Use the same cells for which specific gravity was measured.]	**[Quarterly]**	FIST 3-6 Section 1.5 B PEB 55 Appendix 1
[Evaluate the charger panel voltmeter with a digital voltmeter.]	**[Annually]**	FIST 3-6 Section 1.8 C PEB 55 Appendix 1
Flame arresters should be inspected annually.	Annually	FIST 3-6 Section 8.3
[Measure and record specific gravity readings of every cell.]	**[Annually]**	FIST 3-6 Section 1.4 C PEB 55 Appendix 1
[Measure and record temperature readings of every cell annually.]	**[Annually]**	PEB 55 Appendix 1
[Measure, record, and compare to the installed baseline "as-left" readings the resistance of each battery connection.]	**[Annually]**	FIST 3-6 Section 1.6 B PEB 55 Appendix 1
Transfer yearly battery measurements from near the battery to a permanent file.	Annually	FIST 3-6 Section 1.10
[Perform a capacity test.]	**[5 Years – annually if less than 90 percent of original rating. Annual performance tests of battery capacity should be made on any battery that shows signs of degradation or has reached 85 percent of the service life expected for the application. Degradation is indicated**	FIST 3-6 Section 3.2 PEB 55 Appendix 1 PEB 17

Maintenance Task	Frequency	Reference
	when the battery capacity has dropped more that 10 percent of its capacity from its previous performance test, or is below 90 percent of the manufacturer's rating.]	

2.3.1 Flooded, Wet Cell, Vented Lead Acid Batteries Including Lead Calcium – Optional Instructions

Maintenance Task	Frequency	Reference
Check battery float voltage on control panel against the correct value.	Shift	FIST 3-6 Section 4.3 A
Measure and record specific gravity readings of pilot cell.	Monthly	FIST 3-6 Section 4.4 A
Measure battery float voltage with a digital voltmeter to the nearest 0.01V. Record voltage and compare battery float voltage across battery terminals with charger reading and battery bus voltmeter.	Monthly	FIST 3-6 Section 4.3 B
Measure and record individual cell voltages.	Quarterly	FIST 3-6 Section 4.3 C
Measure and record the temperature of 10 percent of all cells.	Quarterly	FIST 3-6 Section 4.5 B
Measure and record specific gravity readings of every cell.	Annually	FIST 3-6 Section 4.4 C
Add water to water level.	2 to 3 Years	FIST 3-6 Section 4.6

2.4 Valve Regulated, Lead Acid (Gel Cell) Batteries

Maintenance Task	Frequency	Reference
[Check charger voltmeter for correct reading.]	**[Plant rounds]**	FIST 3-6 Section 5.7 B PEB 55 Appendix 2

Maintenance Task	Frequency	Reference
[Check and record the float voltage across the whole battery with an accurate digital voltmeter monthly. Compare this reading to the panel voltmeter and adjust the panel meter to agree with the digital meter, if necessary, monthly.]	**[Monthly]**	FIST 3-6 Section 5.7 E PEB 55 Appendix 2
[Measure with digital voltmeter and record specific gravity readings of pilot cell.]	**[Monthly]**	FIST 3-6 Section 5.7 D PEB 55 Appendix 2
[Perform visual inspection. Check for: general cleanliness of the battery, mounting rack, and battery room; electrolyte leaks and cover integrity; corrosion at terminals, connectors, racks, and cabinets; ambient temperature and make sure ventilation devices (fans and vents) are operable; availability and condition of all safety equipment, gloves, aprons, face shields, etc.; full gallon of labeled neutralizing solution, cleanliness and operability of eyewash station or portable eyewash equipment; operation and body wash station; a class C fire extinguisher and check that it has been inspected and tested according to schedule; and availability of insulated tools and utensils.]	**[Monthly]**	FIST 3-6 Section 5.6 A PEB 55 Appendix 2
[Measure and record the resistance of 25 percent of the connections and compare to prior readings quarterly. Use different connections each quarter.]	**[Quarterly]**	FIST 3-6 Section 5.9 B PEB 55 Appendix 2
[Measure the temperature of each individual cell, record and compare to prior readings.]	**[Quarterly]**	FIST 3-6 Section 5.8 B PEB 55 Appendix 2
[Perform internal resistance	**[Quarterly]**	FIST 3-6 Section 5.10 B

Maintenance Task	Frequency	Reference
and compare the results with initial records.]		PEB 55 Appendix 2
[Measure with a digital voltmeter and record individual cell voltages.]	**[6 Months]**	FIST 3-6 Section 5.7 F PEB 55 Appendix 2
[Perform a capacity test.]	**[Annually; bi-annually if capacity is below 90 percent of original capacity. A performance test of the battery capacity should be given at 1-year intervals until it shows signs of degradation, at which time semiannual performance tests should be given. Degradation is indicated when the battery capacity drops more than 10 percent from its capacity on the previous performance test, or is below 90 percent of the manufacturer's published ratings.]**	FIST 3-6 Section 5.11 B PEB 55 Appendix 2 PEB 17
Check accuracy of the thermometer used for cell temperatures.	Annually	FIST 3-6 Section 5.8 A
[Measure and record the resistance of all connections.]	**[Annually]**	FIST 3-6 Section 5.9 C PEB 55 Appendix 2

2.5 Vented Nickel Cadmium Batteries (NiCad) and NiCad Batteries Used for Microwave and UHF Equipment

Maintenance Task	Frequency	Reference
[Check battery float voltage on control panel against the correct value.]	**[Plant rounds]**	FIST 3-6 Section 6.6 A PEB 55 Appendix 3
Measure voltage across battery terminals using a digital voltmeter and record voltage and	Monthly	FIST 3-6 Section 6.6 D

Maintenance Task	Frequency	Reference
compare battery float voltage with charger panel voltmeter reading.		
[Perform monthly visual inspection. Check for: general cleanliness of the battery, mounting rack, and battery room; check for electrolyte leaks and cracks in cells, corrosion at terminals, connectors, racks, and cabinets; ambient temperature and make sure ventilation devices (fans and vents) are operable; charger and voltage output; availability and condition of all safety equipment, gloves, aprons, face shields, etc.; full gallon of labeled neutralizing solution; cleanliness and operability of eyewash station or portable eyewash equipment; operation and body wash station, availability of insulated tools and utensils. Check the electrolyte level in every cell during the visual inspection.]	**[Monthly]**	FIST 3-6 Section 6.8 A, 6.11 PEB 55 Appendix 3
[Measure and record the temperature of the pilot cell electrolyte.]	**[Quarterly]**	FIST 3-6 Section 6.7 A PEB 55 Appendix 3
[Measure voltage with a digital voltmeter of the pilot cell and overall battery terminals and record them on form POM 133C.]	**[Quarterly]**	FIST 3-6 Section 6.6 E PEB 55 Appendix 3
Flame arresters should be inspected annually.	Annually	FIST 3-6 Section 8.3
[Measure the voltage with a digital voltmeter of every cell and record. Compare to previous readings.]	**[6 Months]**	FIST 3-6 Section 6.6 F PEB 55 Appendix 3
[Annually record the resistance of all the connections. Compare values to baseline.]	**[Annually]**	FIST 3-6 Section 6.4 A PEB 55 Appendix 3
[The charger voltmeter should be checked against an	**[Annually]**	FIST 3-6 Section 6.5 A PEB 55 Appendix 3

Maintenance Task	Frequency	Reference
accurate digital voltmeter at least once a year.]		
[Perform capacity test.]	**[5 Years; annually if less than 90 percent of original rating.]**	FIST 3-6 Section 6.9 B, C PEB 55 Appendix 3
[Measure and record the specific gravity readings of every cell.]	**[5 Years]**	FIST 3-6 Section 6.12 PEB 55 Appendix 3

2.6 Battery Chargers

Maintenance Task	Frequency	Reference
[Check the panel voltmeter to see if the correct float voltage is being used for charging.]	**[Plant rounds]**	FIST 3-6 Section 1.9 A PEB 55 Appendix 4
[Check each charger by turning off one, then the other, and see if each charger will carry the total load.]	**[Quarterly]**	FIST 3-6 Section 1.9 B PEB 55 Appendix 4
[Annually check the enclosure to ensure it is in good overall condition. Look for signs of heating, water damage, corrosion, loose hardware, excessive dust and debris, damage, and varmints. Check wiring insulation for signs of damage are a result of overheating or age.]	**[Annually]**	PEB 55 Appendix 4
[Annually ensure connections on the charger are properly torqued, free of corrosion, appropriately crimped, and are in good overall condition. Both AC and DC connections should be examined to ensure connection integrity.]	**[Annually]**	PEB 55 Appendix 4

2.7 Battery Monitoring System

Maintenance Task	Frequency	Reference
[Maintenance of a battery monitoring system must include a quick check of the unit for any alarm indications or that the unit has power.]	**[Weekly]**	PEB 49
[Battery maintenance tasks may be replaced by the battery monitoring system if the monitoring system is queried on a monthly basis. Table for flooded lead acid is provided.]	**[Monthly]**	PEB 49
[Inspect unit for indication of power failure or alarms.]	**[Weekly]**	PEB 49
[Query battery monitor and examine data.]	**[Monthly]**	PEB 49
[Verify monitoring system battery float voltage.]	**[Annually]**	PEB 49
[Verify monitoring system cell voltages to manual readings at the battery cells.]	**[Annually]**	PEB 49
[Verify monitoring system overall battery current.]	**[When performing battery capacity test.]**	PEB 49
[Verify monitoring system cell connection resistance.]	**[When performing battery capacity testing.]**	PEB 49
[Verify monitoring system battery room temperature.]	**[Monthly]**	PEB 49
[Verify monitoring system cell temperatures.]	**[When performing battery capacity testing.]**	PEB 49
Verify monitoring system cell fluid levels.	Quarterly	PEB 49
Verify monitoring system cell specific gravity.	When performing battery capacity testing.	PEB 49

2.8 Bushings

Maintenance Task	Frequency	Reference
Visual inspection of porcelain and oil levels.	Annually with binoculars	FIST 3-2 Section IV B
IR thermal scans should be performed regularly (e.g., annually) on GE Type U Bushings.	Annually	PEB 1
Inspect transformer bushings.	Annually	FIST 3-30 Section 4.1.8
IR scan of transformer bushings and all wiring.	Annually	FIST 3-30 Sections 3.2.5, 4.1.8
[The following visual inspections must be performed annually for air and air blast circuit breakers: check oil level gauges of oil-filled bushings. Check for chipped or broken porcelain, excessive dirt film, oil level and oil or compound leaks.]	**[Annually]**	PEB 47
[The following visual inspections must be performed annually for oil circuit breakers: check oil level gauges of tanks and oil-filled bushings. Check for chipped or broken porcelain, excessive dirt film, oil level, and oil or compound leaks.]	**[Annually]**	PEB 47
Doble tests of all Type U bushings regularly (e.g., every one to three years) and compare the data against previous test results and nameplate data.	1 to 3 years	PEB 1
Doble test bushings and breaker (Section 5.1.2, "no more than 2 years should elapse between external inspections.")	2 years	FIST 3-16 Section 5.2 G
In-depth inspection of bushings, cleaning waxing if needed.	3 to 5 years	FIST 3-30 Section 4.1.8
Power factor tests, radio-influence-voltage, DC insulation resistance, and testing oil or compound for moisture.	3 to 5 years	FIST 3-2 Section IV C
Visual inspection of terminal	3 to 5 years	FIST 3-2 Section IV A

Maintenance Task	Frequency	Reference
caps, capacitance taps and power-factor test electrodes, cement, gaskets, metal pads, and solder seals.		1-6
Doble test transformer bushing: capacitance, dielectric loss, power factor/dissipation factor, partial discharge.	3 to 5 years. As the bushings age and begin to deteriorate, reduce the testing interval to 1 year.	FIST 3-30 Sections 4.1.8, 4.7; Table 17
[The following preventive maintenance must be performed on a 5-year interval for air and air blast circuit breakers: Clean porcelain with water or a suitable cleaner. Repair chipped spots by painting with lacquer such as 1201 glyptal. Inspect gaskets for leaks. Tighten bolts. Check insulation resistance with contacts closed with Doble test set, Megger®, or Hipot. (See FIST 3-31, Section 8.4, for instructions on testing bushings.) Check oil sample from bottom of bushing for dielectric strength and dissolved gas analysis (DGA) and presence of water and dirt which may be entering at top. Replace or replenish oil if necessary.]	**[5 years]**	PEB 47
[The following preventive maintenance must be performed on a 5-year interval for oil circuit breakers: Clean porcelain with water or a suitable cleaner. Repair chipped spots by painting with lacquer such as 1201 glyptal. Remove and clean interphase barriers. Inspect gaskets for leaks. Tighten bolts. Check insulation resistance with contacts closed with Doble test set, Megger, or Hipot. (See FIST 3-31, Section 8.4, for instructions.) Check oil sample from bottom of bushing for dielectric strength and DGA and presence of water and dirt which may be	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
entering at top. Replace or replenish oil if necessary.]		

2.9 Buswork, Enclosures, and Insulators

Maintenance Task	Frequency	Reference
[Semi-annually or after a switch has carried heavy short-circuit current, perform a visual inspection of the visible components of the disconnect switch. Insulating members: Check the overall cleanliness; check for tracking; inspect for cracked or broken segments.]	**[6 months]**	PEB 46
[The following visual inspections must be performed annually for air and air blast circuit breakers: Check for presence of foreign materials, birds' nests, etc., in or near connecting buswork; loose or overheating connections; and loose or broken frame ground connection.]	**[Annually]**	PEB 47
Check dry type transformer enclosures and vaults/rooms for dirt accumulation on transformer surfaces and debris near or against enclosures.	Annually	FIST 3-30 Section 3.3.1
For PM purposes, it is recommended that a thermal analysis survey be performed annually.	Annually	FIST 4-13 Section 6.3.1
[The following visual inspections must be performed annually for air and air blast circuit breakers: Check for chipped or broken porcelain, or excessive dirt film.]	**[Annually]**	PEB 47
[The following visual	**[Annually]**	PEB 47

Maintenance Task	Frequency	Reference
inspections must be performed annually for oil circuit breakers: Check for chipped or broken porcelain, excessive dirt film. Check for presence of foreign materials, birds' nests, etc., in or near connecting buswork; loose or overheating connections; and loose or broken frame ground connections.]		
[Check for carbon tracking on insulation and insulators on dry type transformers.]	**Annually**	FIST 3-30 Section 3.1.1
For PM purposes, it is recommended that a thermal analysis survey be performed annually: Insulators.	Annually	FIST 4-13 Section 6.3.1
[Every 3 years for outdoor installation and every 6 years for indoor installation, perform major preventive maintenance on the disconnect switch: Insulation surfaces should be inspected and cleaned if necessary; check for chipped or broken porcelain, excessive dirt film, and tracking, clean as necessary; replace broken insulators; tighten base and cap bolts.]	**[3 years outdoors; 6 years indoors]**	PEB 46
[The following preventive maintenance must be performed on a 5-year interval for air and air blast circuit breakers: Clean porcelain with water or a suitable cleaner; repair chipped spots by painting with lacquer such as 1201 glyptal; tighten bolts; check insulation resistance with contacts closed with Doble test set, Megger, or Hipot; tighten all bus and ground connections and inspect for heating.]	**[5 years]**	PEB 47
[The following preventive maintenance must be	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
performed on a 5-year interval for oil circuit breakers: Clean porcelain with water or a suitable cleaner; repair chipped spots by painting with lacquer such as 1201 glyptal; remove and clean interphase barriers; inspect gaskets for leaks; tighten bolts; check insulation resistance with contacts closed with Doble test set, Megger, or Hipot (See FIST 3-31, Section 8.4, for instructions); tighten all bus and ground connections and inspect for heating; refinish contact surfaces if they have been overheated.]		
[Check frame, panel, and cabinets for loose bolts, condition of paint, and cleanliness.]	**[5 years]**	PEB 47
[Tighten all bus and ground connections and inspect for heating. Refinish contact surfaces if they have been overheating. Inspect ground cable to see that it is not loose or broken.]	**[5 years]**	PEB 47
[Semi-annually or after a switch has carried heavy short-circuit current, perform a visual inspection of the visible components of the disconnect switch. Insulating members: Check the overall cleanliness; check for tracking; inspect for cracked or broken segments.]	**[6 months]**	PEB 46

2.10 High Voltage Cables

Maintenance Task	Frequency	Reference
For PM purposes, it is recommended that a thermal analysis survey be performed	Annually	FIST 4-13 Section 6.3.1

annually.		
[DC, high-potential tests of cables need to be conducted only at intervals of 5 years].	**[5 years]**	FIST 3-31 Section 49 PEB 55 Appendix 5

2.11 Carbon Dioxide Systems

Maintenance Task	Frequency	Reference
[Inspect the CO_2 system. **• For low-pressure storage units, the pressure gauge shows normal pressure, that the tank shutoff valve is open, and that the pilot pressure supply valve is open. Liquid level gauge should be observed. If at any time a container shows a loss of more than 10 percent, it should be refilled unless the minimum gas requirements are still provided.** **• CO_2 storage is connected to discharge piping and actuators.** **• All manual actuators are in place and tamper seals are intact.** **• Nozzles are connected, properly aligned, and free from obstructions and foreign matter.** **• Detectors are in place and free from foreign matter and obstructions.** **• The system control panel is connected and showing the "normal-ready" condition.** **• All gauges are reading normal.]**	**[Monthly]**	FIST 5-12 Section 15 PEB 55 Appendix 6
Check the electrical control features at intervals of not more than 1 month by means of the test devices where these are provided.	Monthly	FIST 5-2 Section 6.4.3. (2)
[Weigh all CO_2 cylinders at intervals of not more than 6 months and replace	**[6 months]**	FIST 5-2 Section 6.4.3 (1) FIST 5-12 Section 7.2

Maintenance Task	Frequency	Reference
cylinders in which the CO_2 content weighs less than 90 percent of the weight marked on the cylinder by the supplier. A record of the weights should be kept.]		FIST 5-12 Section 12.2 PEB 55 Appendix 6
[Annually, a functional test of the control/protection circuits should be performed. This test should include verification that the unit differential relay would initiate CO_2 discharge. Although discharge of CO_2 is not required during this test, operation of the discharge valve or pneumatic/electrical discharge devices should be verified.]	**[Annually]**	FIST 5-2 Section 6.4.3 (4) FIST 5-12 Section 9.2 FIST 5-12 Section 15 Table 2 PEB 55 Appendix 6
Staff must be trained annually in the proper operation and maintenance of the CO_2 system.	Annually	FIST 5-12 Section 14 FIST 5-12 Section 15 Table 2
Check calibration of the low-pressure system liquid level gauge.	Annually	FIST 5-12 Section 15 Table 2
Observe low-pressure system liquid level gauge for losses.	Weekly	FIST 5-12 Section 15 Table 2
[Manually operate routing valves.]	**[Annually]**	FIST 5-2 Section 6.4.3 (4) FIST 5-12 Section 15 Table 2 PEB 55 Appendix 6
Perform emergency manual discharge and evacuation drills.	Annually	FIST 5-12 Section 15 Table 2
[A CO_2 system functional test should be performed simulating an actual fire using smoke bombs, local heaters, or other methods to test operation of the detectors and sensors. This test should be repeated every 5 years.]	**[5 years]**	FIST 5-12 Section 9.2 FIST 5-12 Section 15 Table 2 PEB 55 Appendix 6
Pressure test system hoses including flexible connectors.	5 Years	FIST 5-12 Section 15 Table 2

Maintenance Task	Frequency	Reference
[CO_2 cylinders must also be hydrostatically tested every 12 years or before refilling if not hydrostatically tested in the last 5 years.]	**[12 years, before refilling if not hydrostatic tested in last 5 years.]**	FIST 5-12, Sections 6.4.3. (5); 7.2; 12.3; 15 Table 2 PEB 55, Appendix 6

2.12 Circuit Breakers

2.12.1 Molded Case

Maintenance Task	Frequency	Reference
Thermal analysis survey be performed annually of circuit breakers.	Annually	FIST 4-13, Section 6.3.1 PEB 45
Routine trip testing of molded case circuit breakers should be performed every 3 to 5 years.	3 to 5 years	FIST 3-16, Section 2
[Visual inspection of critical molded case circuit breakers (MCCB).]	**[6 years]**	PEB 45
[Operate critical MCCBs on and off 2 or 3 times once every 6 years]	**[6 years]**	PEB 45
[Thermal magnetic-trip test for critical MCCBs.]	**[6 years]**	PEB 45
Insulation resistance tests for critical MCCBs.	6 years	PEB 45
Contact resistance tests for critical MCCBs.	6 years	PEB 45
[Instantaneous trip tests for critical MCCBs.]	**[6 years]**	PEB 45
[Review equipment ratings.]	**[5 years]**	PEB 45
IR Scan.	Annually	PEB 45

2.12.2 Low-Voltage Circuit Breakers

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
Thermal analysis survey be performed annually of circuit breakers.	Annually	FIST 4-13 Section 6.3.1
Low-voltage circuit breakers operating at 600V alternating current (AC) and below should be inspected and maintained very 1 to 3 years.	1 to 3 years	FIST 3-16 Section 3
An initial check of the breaker should be made in the TEST position prior to withdrawing it from to enclosure.	1 to 3 years	FIST 3-16 Section 3.2a
Insulating parts, including bushings, should be wiped clean of dust and smoke.	1 to 3 years	FIST 3-16 Section 3.2b
The alignment and condition of the movable and stationary contacts should be checked and adjusted.	1 to 3 years	FIST 3-16 Section 3.2c
Check arc chutes.	1 to 3 years	FIST 3-16 Section 3.2d
Inspect breaker operating mechanism for loose hardware and missing or broken cotter pins, etc. Examine cam, latch, and roller surfaces for damage or wear.	1 to 3 years	FIST 3-16 Section 3.2e
Clean and relubricate operating mechanism with a light machine oil (SAE-20 or 30) for pins and bearings.	1 to 3 years	FIST 3-16 Section 3.2f
Set breaker operating mechanism adjustments.	1 to 3 years	FIST 3-16 Section 3.2g
Replace contacts if badly worn or burned and check control	1 to 3 years	FIST 3-16 Section 3.2h

Maintenance Task	Frequency	Reference
device for freedom of operation.		
Inspect wiring connections for tightness.	1 to 3 years	FIST 3-16 Section 3.2i
Check after servicing circuit breaker to verify the contacts move to the fully opened and fully closed positions, that there is an absence of friction or binding, and that electrical operation is functional.	1 to 3 years	FIST 3-16 Section 3.2j
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.	**[2 years]**	FIST 3-8 Section 9.2
[Breaker time-travel (motion analysis)]	**[3 years]**	PEB 47
[Insulation resistance test with the use of a megohmmeter (Megger) or by performing a power factor measurement (Doble).]	**[3 years]**	PEB 47

2.12.3 Medium-Voltage Air Circuit Breaker

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
Medium-voltage circuit breakers which operate in the range of 600V to 15,000V should be inspected and maintained annually or after every 2,000 operations, whichever comes first.	Annually or 2,000 operations	FIST 3-16 Section 4
Clean the insulating parts including the bushings.	Annually or 2,000 operations	FIST 3-16 Section 4.3a
Check the alignment and condition of movable and stationary contacts.	Annually or 2,000 operations	FIST 3-16 Section 4.3b
See that bolts, nuts, washers, cotter pins, and all terminal connections are in place and tight.	Annually or 2,000 operations	FIST 3-16 Section 4.3c
Check arc chutes for damage.	Annually or 2,000 operations	FIST 3-16 Section 4.3d
Clean and lubricate the operating mechanism and adjust it.	Annually or 2,000 operations	FIST 3-16 Section 4.3e
Check after servicing circuit breaker to verify the contacts move to the fully opened and fully closed positions, that there is an absence of friction or binding, and that electrical operation is functional.	Annually or 2,000 operations	FIST 3-16 Section 4.3f
[Inspection of foundation, panels and cabinets, oil levels, breathers and vents, bushings and insulators, frame, tanks, and valves, fuses and mountings, main terminals and ground connections, closing solenoid air cylinder,	**[Annually]**	PEB 47

Maintenance Task	Frequency	Reference
motor and spring, tripping solenoid, operations counter, mechanism cabinet, cabinet lights and heaters, power supplies and wiring.]		
Thermal analysis survey be performed annually of circuit breakers.	Annually	FIST 4-13 Section 6.3.1
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.	**[2 years]**	FIST 3-8 Section 9.2
[Insulation resistance test with the use of a megohmmeter (Megger) or by performing a power factor measurement (Doble).]	**[3 years]**	PEB 29 PEB 47
[Breaker time-travel (motion analysis)]	**[3 years]**	PEB 47
[Measure the contact resistance across each pole.]	**[3 years]**	PEB 47
[Check frame, panel, and cabinets for loose bolts, condition of paint, cleanliness.]	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
[Check to see that screens and baffles in vents or breathers are not obstructed or broken.]	**[5 years]**	PEB 47
[Clean porcelain with water or a suitable cleaner. Repair chipped spots by painting with lacquer such as 1201 glyptal. Inspect gaskets for leaks. Tighten bolts. Check insulation resistance with contacts closed with Doble test set, Megger, or Hipot. Check oil sample from bottom of bushing for dielectric strength and DGA, and presence of water and dirt which may be entering at top.]	**[5 years]**	PEB 47
[Tighten all bus and ground connections and inspect for heating. Refinish contact surfaces if they have been overheating. Inspect ground cable to see that it is not loose or broken.]	**[5 years]**	PEB 47
[Remove arc shoots so that the contacts can be inspected. Dress contacts, if rough, with a fine file. It is necessary to carefully remove only the projecting beads. Pits in a flat, smooth surface are not objectionable. Check contact drop with "ductor" or by direct current (DC) millivolt drop with a micro-ohm meter.]	**[5 years]**	PEB 47
[Check springs for loss of temper, breaks, or rust deterioration.]	**[5 years]**	PEB 47
[Check flexible shunts at contact hinges for overheating and fraying. Tighten connections.]	**[5 years]**	PEB 47
[Check arc-rupturing blowout coils, magnetic circuit, arc chutes, de-ion grids, or other interrupters for proper	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
operation.]		
[Perform a leak test to check seals and piping.]	**[5 years]**	PEB 47
[Check contact crosshead for misalignment, breaks, bends, or looseness on lift rod.]	**[5 years]**	PEB 47
[Check contact lift rods for breaks, weakening, or warping, and pulling out at ends. Check adequacy of guides.]	**[5 years]**	PEB 47
[Check for loose locknuts, setscrews, keys, bearings, bent rods, or twisted shafts, etc. Clean moving parts of rust, dirt, and accumulated grease and oil. Wash out bearings, pivots, and gears with a suitable cleaner; and operate breaker several times to work out dirt and old lubricant. Lubricate with new grease or oil. In cold climates, it is important to use lubricant that will not stiffen with cold. Wipe off excess oil.]	**[5 years]**	PEB 47
[Observe mechanism during several closing operations to see that everything is in proper working order. Check solenoid plunger for sticking in guides. Check coil resistance with an ohmmeter and insulation resistance with an appropriate insulation tester (Megger or Hipot). Test phase to phase and phase to ground. Record both "as-found" and "as-left" results. Dismantle air cylinder and clean and relubricate. Check motor. Check closing springs for proper tension and closing energy.]	**[5 years]**	PEB 47
[Observe mechanism during several tripping operations to see that everything is in	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
working order. Check pins, bearings, and latches for wear, binding, and misalignment. Clean and relubricate. Check latch carefully to see that it is not becoming worn so that it would unlatch from vibration or stick and fail to trip. Tighten bolts and screws.]		
[Observe operation during electrical tripping. See that full energy action of plunger is obtained. Check plunger for sticking in guides. Check coil and insulation resistance.]	**[5 years]**	PEB 47
[Check condition of contacts and refinish with fine file if burned or corroded. Check contact springs, operating rods, and levers. Check closing and opening position with respect to main contacts while breaker is being slowly closed and opened manually. Certain auxiliary contacts used for special purposes may require close adjustment in this respect.]	**[5 years]**	PEB 47
[See that position indicator or semaphore is properly indicating the breaker position. Check operating rods or levers for loose parts.]	**[5 years]**	PEB 47
[Check for proper setting and adjust as necessary. Clean out and replenish liquid in liquid dashpots.]	**[5 years]**	PEB 47
[Opening and closing breakers several times at intervals, as system operation permits, to reduce contact resistance and heating by wiping the oxide from the contact surfaces.]	**[5 years]**	PEB 47

2.12.4 Medium-Voltage Vacuum Circuit Breaker

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
[Medium-voltage circuit breakers which operate in the range of 600V to 15,000V should be inspected and maintained annually or after every 2,000 operations, whichever comes first.]	**[Annually or 2,000 operations]**	FIST 3-16 Section 4 PEB 55 Appendix 7
[For primary contacts, measuring the change in external shaft position after a period of use can indicate extent of contact erosion.]	**[Annually or 2,000 operations]**	FIST 3-16 Section 4.5a PEB 55 Appendix 7
[Annually check the condition of the vacuum by a Hipot test.]	**[Annually or 2,000 operations]**	FIST 3-16 Section 4.5b PEB 55 Appendix 7
Thermal analysis survey performed annually of circuit breakers.	Annually	FIST 4-13 Section 6.3.1
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure,	**[2 years]**	FIST 3-8 Section 9.2

Maintenance Task	Frequency	Reference
reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.		
[All high-voltage bushings should be inspected periodically to intervals of not over 3-5 years. The inspections should include power-factor tests for all oil filled bushings rated above 115 kV].	**[5 years]**	FIST 3-2 Section IV PEB 55 Appendix 7
[Conduct power factor test (Doble) every 5 years.]	**[5 years]**	PEB 29 Page 40 PEB 55 Appendix 7

2.12.5 Medium-Voltage SF_6 Circuit Breaker

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
[The following visual inspections must be performed monthly for medium voltage SF_6 circuit breakers. The tasks include: record SF_6 gas pressure and gas or tank temperature, record operations counter, check equipment heaters, check operating mechanism condition according to the paragraphs below, and verify breaker position indicating lights to mechanical indicator.]	**[Monthly]**	PEB 55 Appendix 8
[Perform a gas analysis on SF_6 gas annually checking for moisture and SO_2/SOF_2.]	**[Annually]**	PEB 55 Appendix 8
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any	**[2 years]**	FIST 3-8 Section 9.2

Maintenance Task	Frequency	Reference
change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.		
[The following visual inspections must be performed every 3 years for medium voltage SF_6 circuit breakers. These inspections include: Check foundation, check equipment grounds, check breaker frame, check paint, check breaker housing, check breaker bushings, and check gas piping.]	**[3 years]**	PEB 55 Appendix 8
[All high-voltage bushings should be inspected periodically to intervals of not over 5 years. The inspections should include power-factor tests for all oil filled bushings rated above 115 kV].	**[5 years]**	FIST 3-2 Section IV PEB Appendix 8
[Conduct circuit breaker timing test every 5 years.]	**[5 years]**	PEB 29 Page 11 PEB 55 Appendix 8
[Perform a contact resistance test every 6 years.]	**[6 years]**	PEB 55 Appendix 8

2.12.6 Medium-Voltage Oil Breakers

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8, Section 9.4
Medium-voltage circuit breakers which operate in the range of 600V to 15,000V should be inspected and maintained annually or after every 2,000 operations, whichever comes first.	Annually or 2,000 operations	FIST 3-16 Section 4
Check the condition, alignment, and adjustment of the contacts.	Annually or 2,000 operations	FIST 3-16 Section 4.4a
Thoroughly clean the tank and other parts which have been in contact with the oil.	Annually or 2,000 operations	FIST 3-16 Section 4.4b
Test the dielectric strength of the oil and filter or replace the oil if the dielectric strength is less than 22 kV.	Annually or 2,000 operations	FIST 3-16 Section 4.4c
Check breaker and operating mechanisms for loose hardware and missing or broken cotter pins, retaining rings, etc.	Annually or 2,000 operations	FIST 3-16 Section 4.4d
Adjust breaker.	Annually or 2,000 operations	FIST 3-16 Section 4.4e
Clean and lubricate operating mechanism.	Annually or 2,000 operations	FIST 3-16 Section 4.4f
Before replacing the tank, check to see there is no friction or binding that would hinder the breaker's operation. Also check the electrical operation.	Annually or 2,000 operations	FIST 3-16 Section 4.4g
When replacing the tank and refilling it with oil, be sure the gaskets are undamaged and all nuts and valves are tightened properly to prevent leakage.	Annually or 2,000 operations	FIST 3-16 Section 4.4h

Maintenance Task	Frequency	Reference
Thermal analysis survey be performed annually of circuit breakers.	Annually	FIST 4-13 Section 6.3.1
[Visual inspections. Check foundation for cracks and settling. Check for proper alignment and loose or broken parts. Check for oil leaks and note tank temperature by touch. Check oil level gauges of tanks and oil-filled bushings. Check panels of insulation material for cracks and cleanliness. Check condition of enclosing cabinets including hinges, latches, locks, and door gaskets. Check for chipped or broken porcelain, excessive dirt film, oil level, and oil or compound leaks. Check general condition and tightness of fuses and mountings. Check for presence of foreign materials, bird nests, etc., in or near connecting buswork; loose or overheating main terminal connections; and loose or broken frame ground connections. Visual inspection to see that the closing solenoid air cylinder, motor, or spring are in operating condition. Drain condensation from air cylinder. Visually inspect breaker position indicating light if the breaker is closed to ensure the solenoid trip device is in operating condition. Observe and record reading of operation counter. Check condition of the mechanism cabinet metal and hardware. See that door gaskets are tight and properly exclude dust and dirt. Check cabinet heaters and see that they are in service in cold weather. Replace burnt-out lamps. See	**[Annually]**	PEB 47

Maintenance Task	Frequency	Reference
that all power and control circuit switches are closed and fuses are in place. Inspect wiring for damaged insulation.]		
[Insulating oil, DGA, and dielectric strength.]	**[Annually]**	PEB 47
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.	**[2 years]**	FIST 3-8 Section 9.2
[Breaker time-travel (motion analysis)]	**[3 years]**	PEB 47
[Insulation resistance test with the use of a megohmmeter (Megger) or by performing a power factor measurement (Doble).]	**[3 years]**	PEB 47
[Measure the contact resistance across each pole.]	**[3 years]**	PEB 47
[Preventive maintenance.]	**[3 years]**	PEB 47
All high-voltage bushings should be inspected periodically to intervals of not	3 to 5 years	FIST 3-2 Section IV

Maintenance Task	Frequency	Reference
over 3-5 years. The inspections should include power-factor tests for all bushings rated above 115 kV.		

2.12.7 High-Voltage Breakers

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
Thermal analysis survey be performed annually of circuit breakers.	Annually	FIST 4-13 Section 6.3.1
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.	**[2 years]**	FIST 3-8 Section 9.2
Visually inspect PCB externals and operating mechanism.	2 years for external inspections	FIST 3-16 Section 5.2a
Check oil dielectric strength and color for oil breakers.	2 years for external inspections	FIST 3-16 Section 5.2b

Maintenance Task	Frequency	Reference
Observe breaker operation under load.	2 years for external inspections	FIST 3-16 Section 5.2c
Operate breaker manually and electrically and observe for malfunction.	2 years for external inspections	FIST 3-16 Section 5.2d
Trip breaker from protective relays.	2 years for external inspections	FIST 3-16 Section 5.2e
Check operating mechanism adjustments.	2 years for external inspections	FIST 3-16 Section 5.2f
Doble test bushings and breaker.	2 years for external inspections	FIST 3-16 Section 5.2g
Measure contact resistance.	2 years for external inspections	FIST 3-16 Section 5.2h
Make time-travel or motion-analyzer records.	2 years for external inspections	FIST 3-16 Section 5.2i
High voltage circuit breakers – most manufacturers recommend complete inspections, external and internal, at intervals of 6 to 12 months. No more than 2 years should elapse between external inspections or 4 years between internal inspections.	2 years for external inspections; 4 years for internal inspections	FIST 3-16 Section 5.1
All high-voltage bushings should be inspected periodically to intervals of not over 3 to 5 years. The inspections should include power-factor tests for all bushings rated above 115 kV.	3 to 5 years	FIST 3-2 Section IV
[Insulation resistance test with the use of a megohmmeter (Megger) or by performing a power factor measurement (Doble).]	**[3 years]**	PEB 47
The breaker tanks or contact heads should be opened and the contacts and interrupting parts should be inspected.	4 years	FIST 3-16 Section 5.3

2.12.8 High-Voltage Oil Breakers

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
[Insulating oil, DGA, and dielectric strength.]	**[Annually]**	PEB 47
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found" condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.	**[2 years]**	FIST 3-8 Section 9.2
All high-voltage bushings should be inspected periodically to intervals of not over 3 to 5 years. The inspections should include power-factor tests for all bushings rated above 115 kV.	3 to 5 years	FIST 3-2 Section IV
Power Factor Test – Doble	3 to 6 years	PEB 29 Page 40
[Breaker time-travel (motion analysis)]	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
[Insulation resistance test with the use of a megohmmeter (Megger) or by performing a power factor measurement (Doble).]	**[5 years]**	PEB 47
[Measure the contact resistance across each pole.]	**[5 years]**	PEB 47
[Preventive maintenance.]	**[5 years]**	PEB 47
Circuit breaker timing test.	5 years	PEB 29 Page 11
[Check condition of the frame, tanks, and valves; paint and repaint as necessary. See that oil drain valves that can be operated without wrenches are plugged or locked to prevent unauthorized opening. Tighten bolts. Clean exterior of tanks. Inspect underside of cover for moisture and rust, and clean and repaint as necessary. Check tank liners and interphase barriers.]	**[5 years]**	PEB 47
[Clean dirty gauge glasses and connections into tank.]	**[5 years]**	PEB 47
[Check to see that screens and baffles in vents or breathers are not obstructed or broken.]	**[5 years]**	PEB 47
[Clean porcelain with water or a suitable cleaner. Repair chipped spots by painting with lacquer such as 1201 glyptal. Remove and clean interphase barriers. Inspect gaskets for leaks. Tighten bolts. Check insulation resistance with contacts closed with Doble test set, Megger, or Hipot (See FIST 3-31 Section 8.4 for instructions). Check oil sample from bottom of bushing for dielectric strength and DGA and presence of water and dirt.]	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
[Tighten all bus and ground connections and inspect for heating. Refinish contact surfaces if they have been overheated. Inspect ground cable to see that it is not loose or broken.]	**[5 years]**	PEB 47
Remove the tanks or drain out oil so that the contacts can be inspected. Dress contacts, if rough, with a fine file. It is necessary to carefully remove only the projecting beads. Pits in a flat, smooth surface are not objectionable. Check contact drop with "ductor" or by direct current millivolt drop with a micro-ohm meter.	**[5 years]**	PEB 47
[Check the contact pressure springs for loss of temper, breaks, or rust deterioration.]	**[5 years]**	PEB 47
[Check flexible shunts at contact hinges for overheating and fraying. Tighten connections.]	**[5 years]**	PEB 47
[Check arc-rupturing blowout coils, arc chutes, de-ion grids, oil blast, or other interrupters for proper operation.]	**[5 years]**	PEB 47
[Check contact crosshead for misalignment, breaks, bends, or looseness on lift rod.]	**[5 years]**	PEB 47
[Check contact lift rods for breaks, weakening, or warping, and pulling out at ends. Check adequacy of guides.]	**[5 years]**	PEB 47
[Check for loose locknuts, setscrews, keys, bearings, bent rods, or twisted shafts, etc. Clean moving parts of rust, dirt, and accumulated grease and oil. Wash out	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
bearings, pivots, and gears with a suitable cleaner, and operate breaker several times to work out dirt and old lubricant. Lubricate with new grease or oil. In cold climates, it is important to use lubricant that will not stiffen with cold. Wipe off excess oil.]		
[Observe the closing solenoid air cylinder, motor, or spring mechanism during several closing operations to see that everything is in proper working order. Check solenoid plunger for sticking in guides. Check coil resistance with an ohmmeter and insulation resistance with an appropriate insulation tester (Megger or Hipot). Test phase to phase and phase to ground. Record both "as-found" and "as-left" results. Dismantle air cylinder and clean and relubricate. Check motor. Check closing springs for proper tension and closing energy.]	**[5 years]**	PEB 47
[Observe latch and trip mechanism during several tripping operations to see that everything is in working order. Check pins, bearings, and latches for wear, binding, and misalignment. Clean and re-lubricate. Check latch carefully to see that it is not becoming worn so that it would unlatch from vibration or stick and fail to trip. Tighten bolts and screws.]	**[5 years]**	PEB 47
[Observe operation of the tripping solenoid during electrical tripping. See that full energy action of plunger is obtained. Check plunger for sticking in guides.	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
Check coil and insulation resistance.]		
[See that moving parts of the solenoid valves are free to operate. Check for condition of valve seat and refit as necessary. Check resistance and insulation resistance of solenoid coil.]	**[5 years]**	PEB 47
[Check condition of the auxiliary switch contacts and refinish with fine file if burned or corroded. Check contact springs, operating rods, and levers. Check closing and opening position with respect to main contacts while breaker is being slowly closed and opened manually. Certain auxiliary contacts used for special purposes may require close adjustment in this respect.]	**[5 years]**	PEB 47
[See that position indicator or semaphore is properly indicating the breaker position. Check operating rods or levers for loose parts.]	**[5 years]**	PEB 47
[Check the dashpots or snubbers for proper setting and adjust as necessary. Clean out and replenish liquid in liquid dashpots.]	**[5 years]**	PEB 47
[Check dielectric strength of the insulating oil in the main tanks.]	**[5 years]**	PEB 47
[The necessity for filtering the insulating oil will depend on the results obtained from the oil tests and the amount of carbon in the oil. The oil should be filtered if the dielectric strength is below 25 kV or if there is a noticeable amount of carbon	**[5 years]**	PEB 47

Maintenance Task	Frequency	Reference
in suspension or in the bottom of the tank.]		
[Opening and closing breakers several times at intervals, as system operation permits, to reduce contact resistance and heating by wiping the oxide from the contact surfaces.]	**[5 years]**	PEB 47

2.12.9 Circuit Breakers High-Voltage SF_6 Circuit Breaker

Maintenance Task	Frequency	Reference
[Visually check red lights for both the lockout relay and circuit breaker coil continuity once per shift.]	**[Shift]**	FIST 3-8 Section 9.4
[The following visual inspections must be performed monthly for medium voltage SF_6 circuit breakers. The tasks include: Record SF_6 gas pressure and gas or tank temperature, record operations counter, check equipment heaters, check operating mechanism condition according to the paragraphs below, and verify breaker position indicating lights to mechanical indicator.]	**[Monthly]**	PEB 55 Appendix 9
[Perform a gas analysis on SF_6 gas annually checking for moisture and SO_2/SOF_2.]	**[Annually]**	PEB 55 Appendix 9
[Protective circuit functional testing and lockout relay function testing must take place immediately upon installation and/or upon any change in wiring, upon any misoperation, and every 2 years.] The initial functional test must be conducted with the lockout relay in an "as-found"	**[2 years]**	FIST 3-8 Section 9.2

Maintenance Task	Frequency	Reference
condition to prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing.		
[The following visual inspections must be performed every 3 years for medium voltage SF_6 circuit breakers. These inspections include: Check foundation, check equipment grounds, check breaker frame, check paint, check breaker housing, check breaker bushings, and check gas piping.]	**[3 years]**	PEB 55 Appendix 9
[All high-voltage bushings should be inspected periodically to intervals of not over 5 years. The inspections should include power-factor tests for all oil filled bushings rated above 115 kV.]	**[5 years]**	FIST 3-2 Section IV PEB 55 Appendix 9
[Conduct circuit breaker timing test every 5 years.]	**[5 years]**	PEB 29 Page 11 PEB 55 Appendix 9
[Perform a contact resistance test every 6 years.]	**[6 years]**	PEB 55 Appendix 9

2.13 Control Circuits – For Protection Circuits

Maintenance Task	Frequency	Reference
Generator CO_2: Check electrical control circuits and indicating lights.	Monthly	FIST 4-1A Section 2.11.1-13

Maintenance Task	Frequency	Reference
Check the electrical control features at intervals of not more than 1 month by means of the test devices where these are provided. This checks the continuity of the electrical control circuits should the detonators and other devices in the circuit.	Monthly	FIST 5-2 Section 6.4.3 (2)
Annually, each transformer fire suppression system should be tested functionally to ensure that all components of the control circuitry operate correctly.	Annually	FIST 3-33 Section 10
Annually, a functional test of the CO_2 control/protection circuits should be performed. This test should include verification that the unit differential relay would initiate CO_2 discharge.	Annually	FIST 5-12 Section 9.2
[See that all air and air blast breaker power and control circuit switches are closed during annual visual inspections.]	**[Annually]**	PEB 47
[See that all oil circuit breaker power and control circuit switches are closed during annual visual inspections.]	**[Annually]**	PEB 47
[Protective circuit functional testing, including lockout relay testing, must take place every 2 years.] Initiate a lockout relay trip with the protective relay contact. Prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Visually and/or electrically, verify that the lockout relay actually tripped from the protective relay action. Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Verify that every contact in the lockout relay actually has functioned	**[2 years]**	FIST 3-8 Section 8

Maintenance Task	Frequency	Reference
properly. Activate the lockout relay from each protective device. After the first full test of the lockout relay and breakers, the lockout relay may be left in the trip position so as not to repeatedly trigger the lockout coil; a meter, light, buzzer, or existing amber light may be substituted to verify contact operation. Visually check that all alarms, meters, lights, and other indicators have activated. Perform a timing test on the lockout relays and trend data each time testing is performed. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing. Auxiliary relays may be a critical component of protection circuits, and it is important to include these relays when performing functional testing.		
[Functionally test all ICS control, protection, and alarm circuits, including all control-related, protection-related, alarm-related, and other critical inputs and outputs and all status inputs, upon commissioning and every 2 years thereafter.]	**[Commissioning; 2 years]**	FIST 3-33 Section 7.1.2.2
[Maintenance schedule for control circuits functional test control circuits.] Functional testing of control circuits may be considered complete in the course of normal operation. As an example, most of the unit control circuits are functionally operating and therefore tested when the unit is started, in operation and shutdown. This is considered an appropriate functional test of these circuits but must be documented.	**[3 years]**	PEB 43

Maintenance Task	Frequency	Reference
[Critical control circuits must be tested upon installation, every 6 years thereafter, and upon any circuit changes.]	**[6 years]**	PEB 43

2.14 Coupling Capacitors

Maintenance Task	Frequency	Reference
[Annually de-energize and make close visual inspection for bulged case, chipped or cracked bushings, loose connections, and for oil leaks. Check oil level of the basebox by means of the oil gauge.] Clean bushings.	**[Annually]**	PEB 55 Appendix 10
Testing coupling capacitors "as available," when other Doble tests are being made, or whenever there is some doubt about their condition, should be adequate; however, the interval between tests should not exceed 2 years.	2 years	FIST 3-25
[Verify that acceptable instrument transformer output signals are received at the protective relay.]	**[6 years]**	FIST 3-8 Table 1
[Instrument transformer burden measurements.]	**[6 years]**	FIST 3-8 Table 1 FIST 3-8 Section 5.1
[Instrument transformer secondary circuit polarity, phasing, and connections testing.]	**[6 years]**	FIST 3-8 Table 1 FIST 3-8 Section 5.4
[Instrument transformer secondary grounding and insulation resistance tests.]	**[6 years]**	FIST 3-8 Table 1 FIST 3-8 Section 5.2

2.15 Overhead Cranes, Hoists, and Elevators

Maintenance Task	Frequency	Reference
On each shift, before operating the crane, the operator shall perform the following operations: a. Test all controls. Any controls that do not operate properly should be adjusted or repaired prior to the start of any operation. b. Verify operation of the primary upper-limit switch. The trip-setting of the primary upper limit switches shall be checked under no load conditions by inching the block into the limit (running at slow speed).	Shift	FIST 4-1A Section 6.5
All controls shall be tested by the operator before beginning a new shift.	Shift	FIST 4-1A Section 6.8
Overhead crane inspection standards, hoist limit device.	Daily/shift; monthly; annually	FIST 4-1A Section 6.5 Table 2
Overhead crane inspection standards, controllers.	Daily/shift	FIST 4-1A Section 6.5 Table 2
Electrical equipment – Check control levers and pushbuttons for misadjustments, free movement, and for any obstruction that could interfere with proper operation. Check that the controller returns to the off position when the lever is released. Check for excessive wear and contamination by lubricants or other foreign matter. Controls shall be kept clean, and function labels shall be kept legible.	Monthly	FIST 4-1A Section 6.10.7
Warning Devices – Check operation of hoist upper limit switches, without load, by carefully inching into the limit switch. Confirm operation of all	Monthly	FIST 4-1A Section 6.10.7

Maintenance Task	Frequency	Reference
warning devices.		
[Reclamation requires periodic inspections to be performed at least annually: **a. Include pre-inspection safety requirements (e.g., lock and tag requirements) and ensure that the crane is in the proper location for inspection.** **b. Include inspections recommended by the manufacturer or a qualified engineer.** **c. Include items previously listed in "2. Startup and Daily Inspection," "3. Frequent Inspection," "5. Monthly Wire Rope Inspection," "6. Monthly Chain Inspection," and "7. Hook Inspection" (requirements for these are included at the end of this section).** **d. Require a check of all braking systems and motion limit devices which interrupt power or cause a warning to be activated, including hoist limit switches and bridge and trolley travel limit switches, for proper performance. To prevent damage, each motion shall be inched or operated at low speed into the limit device with no load on the crane. The actuating mechanism of the limit switch shall be located so that it will trip the switch, under all conditions, in sufficient time to prevent contact of the hook or load block with any part of the trolley or crane. Check load limiting devices for proper operation.** **e. Require a check of control systems, if applicable, to include electrical apparatus for signs of pitting or any deterioration of visible controller contacts, limit switches, and pushbutton**	**[Annually]**	FIST 4-1A Section 6.5 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
stations. Inspect for dirt, oil, and moisture accumulation].		
[Overhead crane inspection standards, resistors – Every year visually examine resistor tubes for cracks, loose bands and connections, and broken resistance wire. Clean resistor banks if dirty.]	**[Annually]**	FIST 4-1A Section 6.5 Table 2 FIST 4-1B Section 8 PEB 55 Appendix 11
Overhead crane inspection standards, bridge and trolley conductors, and collectors.	Annually	FIST 4-1A Section 6.5 Table 2
Reclamation requires an annual operational test.	Annually	FIST 4-1A Section 6.7
[Annually inspect trolley and bridge motors, gear boxes, and shafts – Check motor brushes for wear and slip rings for pitting. Examine brushes for length and fit. Replace one at a time if badly worn. Inspect commutators for wear, flat spots, high bars discoloration, or ridging. Never touch the commutator with your finger. Check connections to brushes. Look for signs of excessive heat. Re-torque to manufacturer's recommendations as required. Vacuum away carbon dust produced from brush wear. Clean motor air intake screens. Using air, blow dirt out of the interior windings of the motor if required. Grease bearings if not of the sealed type. Test motor insulation.]	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[Annually inspect electrical equipment – Check controller contacts for signs of pitting or any other deterioration. Examine the controller for burned contacts or signs of overheating. Check for	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
excessive wear or looseness of control levers. Vacuum and clean the controller if contaminated with dust and dirt. Lubricate moving parts as needed. Check strain relief on pendent. Check that required control markings are displayed and legible.]		
[Warning devices – Every year check operation of hoist upper, lower, and travel limit switches; check electrical contacts for signs of pitting or any other deterioration. Check levers and cams for adequate lubrication and excessive wear. Verify main disconnect and cab disconnect or breaker meet all code requirements.]	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[Bridge and trolley conductors and collectors – Every year check the contact surfaces of open conductors and collectors for signs of arcing damage, pitting, and corrosion. Check condition of insulators. Clean as required. Check that festoon-type conductor cables move freely with bridge and trolley movement. Check the condition of insulation and for kinking in cable. Check that all guards are in place and secure.]	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[Electric elevator tests – Every year complete the Category 1 test requirements for electric elevators which generally can be characterized as "no-load/low-speed," and involve the following equipment: safeties, standby power operation, firefighters' service, final and normal stopping devices.]	**[Annually]**	FIST 2-10 Section 4.3.1 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
[Hydraulic Elevator Tests – Every Year, complete the following Category 1 test requirements for hydraulic elevators, which involves the following equipment: Relief valve setting and system pressure, flexible hose and fittings, hydraulic cylinder leak test, standby power operation, firefighters' service, power operation of doors, normal and final terminal stopping devices, emergency terminal speed-limiting device, emergency terminal stopping device, pressure switch, oil buffer, safety, governor (if provided), and low oil test.]	**[Annually]**	FIST 2-10 Section 4.4.1 PEB 55 Appendix 11
[Hydraulic Elevator Tests – Every 3 Years, complete the following Category 3 test requirements for hydraulic elevators, which involves the following equipment: Unexposed portions of pistons and pressure vessels (hydrostatic test).]	**[3 years]**	FIST 2-10 Section 4.4.2 PEB 55 Appendix 11
[Electric elevators – The Category 5 test requirements for electric elevators which generally can be characterized as "rated-load/rated-speed," and involve the following equipment: Safeties, braking system, emergency terminal stopping and speed-limiting devices, standby power operation, power opening of doors, leveling zone and leveling speed.]	**[5 years]**	FIST 2-10 Section 4.3.2 PEB 55 Appendix 11
[Hydraulic Elevator Tests – Every 5 years, complete the following Category 5 test requirements for hydraulic elevators, which involves the following equipment:	**[5 years]**	FIST 2-10 Section 4.4.3 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
oil buffer (if provided), safety (if provided), governor (if provided), coated ropes (if provided), rope fastening on pistons (if provided), and over-speed valve.]		

2.16 Overhead Distribution Lines

Maintenance Task	Frequency	Reference
[Ground line inspection – Every 12 years for sound poles, 6 years for minor decay in previous inspection, examine entire structure from ground for the following defects: (1) Excessive checking, cracking, or splitting; especially deep checks in full-length treated poles showing white wood. (2) Woodpecker holes and evidence of insect colonies. (3) Excessive shell decay above ground – note degree. (4) Lightning damage. (5) Damaged or corroded guying. (6) Damaged bracing. (7) If in through-drilled poles the backfill extends above the drilled section – REMOVE! (8) Any other obvious defects.]	**[12 years for sound poles; 6 years for minor decay in previous inspection.]**	FIST 4-6 Section 4.3.2 PEB 55 Appendix 12
Measure and record the pole circumference at the ground line, remove the surface decay down to sound wood, and record the new circumference of the pole.	12 years for sound poles; 6 years for minor decay in previous inspection.	FIST 4-6 Section 4.3.2
[For wood poles and cross arms, if pole top and cross arm defects cannot readily be assessed from the ground, climb the pole for a thorough analysis after determining that	**[12 years for sound poles; 6 years for minor decay in previous inspection.]**	FIST 4-6 Section 4.3.2 PEB 55 Appendix 12

Maintenance Task	Frequency	Reference
it is safe to do so every 12 years for sound poles and every 6 years for minor decay in previous inspection.]		

2.17 Emergency Lighting

Maintenance Task	Frequency	Reference
Operators need to observe all emergency lighting panels and alarms during plant rounds and report any problems to the proper contact.	Plant rounds	PEB 55 Appendix 13
[A functional test shall be conducted on every required battery-powered emergency lighting system at 30-day intervals for a minimum of 30 seconds.]	**[Monthly]**	PEB 34 PEB 55 Appendix 13
[An annual test shall be conducted for 1.5-hr duration.]	**[Annually]**	PEB 34 PEB 55 Appendix 13

2.18 Exciters and Voltage Regulators

Maintenance Task	Frequency	Reference
During plant rounds, operators should inspect the generator exciter and voltage regulator system cubicles, observe all indicating devices, observe any visual and audible anomalies, and report as needed to the appropriate contact.	Operator rounds	PEB 55 Appendix 14
For PM purposes, it is recommended that a thermal analysis survey be performed annually on exciters and voltage regulators.	Annually	FIST 4-13 Section 6.3.1
[Automatic voltage regulator (AVR) equipment shall be	**[5 years]**	PEB 55 Appendix 14

tested and calibrated in conjunction with the balance of the excitation system as often as necessary to maintain calibration/performance, but at least once every 5 years or following any repairs to the excitation system.]		

2.19 Facility Equipment Ratings Reviews

Maintenance Task	Frequency	Reference
[Review the nameplate ratings of the arrestors every 5 years to insure this device is rated appropriately.]	**[5 years]**	PEB 44
[To insure the continued proper operation of MCCBs, an equipment ratings review must be performed every 5 years.]	**[5 years]**	PEB 45
[Review the nameplate ratings of the disconnect switch every 5 years to insure this device is rated appropriately.]	**[5 years]**	PEB 46
[Required ratings for switchyard conductors and bus are developed in coordination with power marketing agencies or local utilities based on the location of the project and at least every 5 years.]	**[5 years]**	PEB 55 Appendix 15
[The required ratings of medium-voltage bus including fuses and power cables 5 kV above are identified when the equipment specifications are prepared and at least every 5 years.]	**[5 years]**	PEB 55 Appendix 15
[The required ratings of generator circuit breakers, including low-voltage (600V and below) draw out air breakers, medium-voltage	**[5 years]**	PEB 55 Appendix 15

(601–15 kV) air and air blast breakers, medium-voltage (601–15 kV) vacuum breakers, medium- and high-voltage SF_6 breakers, high-voltage (greater than [>] 15 kV) oil breakers are identified when the equipment specifications are prepared and at least every 5 years.]		
[The required ratings of instrument transformers including coupling capacitors are identified when the equipment specifications are prepared and at least every 5 years.]	**[5 years]**	PEB 55 Appendix 15
[The required ratings of transmission line and distribution line conductors are identified when the equipment and material specifications are prepared and at least every 5 years.]	**[5 years]**	PEB 55 Appendix 15
[The required ratings of generator step-up transformers including all station and distribution (less than 500 kV amperes (kVA) type transformers, dry type power (500 kVA and larger) transformers, and any oil-filled power transformer are identified when the equipment specifications are prepared and at least every 5 years.]	**[5 years]**	PEB 55 Appendix 15
[Each region shall implement procedures to ensure the adequacy of protective grounds and shall periodically review grounding practices at each facility to determine the proper size, length, and number (if parallel grounds are required) of protective grounds. Regions shall maintain and periodically update a listing of the maximum fault currents at each facility or location where Reclamation employees apply	**[5 years]**	FIST 5-1A PEB 55 Appendix 15

protective grounds. These reviews will be conducted at 5-year intervals or sooner if change in equipment or system conditions call for specific revision.]		
[Each region shall develop a list of all blackstart generators with megawatt capacity, type of unit, date of latest test, starting method. The region shall evaluate the actual capacity of facility energy sources used to start the listed blackstart generators. In addition, each region will coordinate with the respective transmission operator to review the transmission switching requirements of each unit at least every 5 years].	**[5 years]**	PEB 55 Appendix 15

2.20 Protective Relay Settings Review

Maintenance Task	Frequency	Reference
[Fault and load studies and relay settings are required to be evaluated on a 5-year cycle.]	**[5 years]**	FIST 3-8 Section 4.1

2.21 Arc Flash Hazard Analysis

Maintenance Task	Frequency	Reference
[The arc flash hazard analysis must be updated when a major modification or renovation takes place as well as reviewed every 5 years at a maximum.]	**[5 years]**	FIST 5-14 Section 4.4.10

2.22 Fire Detection and Alarm Systems

Maintenance Task	Frequency	Reference
Check the electrical control features at intervals of not more than 1 month by means of the test devices where these are provided. This checks the continuity of the electrical control circuits should the detonators and other devices in the circuits.	Monthly	FIST 5-2 Section 6.4.3 (2)
Visual inspection – Check for a battery room class C fire extinguisher and check that it has been inspected and tested according to schedule.	Monthly	FIST 3-16 Section 1.7
Portable extinguishers shall be inspected monthly for: (1) The extinguisher shall be in its designated place. (2) Access to, or visibility of, the extinguisher shall not be obstructed. (3) The operation instructions on the extinguisher nameplate shall be legible and face outward. (4) Any seals or tamper indicators that are broken or missing shall be replaced. (5) For water types without gauges, their fullness shall be determined by "hefting." (6) Any obvious physical damage, corrosion, leakage, or clogged nozzles shall be noted. (7) Pressure-gauge readings when not in the operable range shall be noted.	Monthly	FIST 5-2 Section 3.3.2
Automatic sprinkler systems are provided with a valved blow-off line. These blow-off lines should be opened monthly.	Monthly	FIST 5-2 Section 6.4.1
[A minimum 30-second monthly backup battery power function test will be performed on the fire detection systems.] This can be accomplished by	**[Monthly]**	PEB 55 Appendix 16

Maintenance Task	Frequency	Reference
holding the test button (if equipped) for 30 seconds, or removing the equipment for the AC power source for a minimum of 30 seconds every month. During the 30-second test, verify the fire detection system is fully operational for the duration of the test by activating the annunciator test. This test can be performed through automated procedures.		
[Annually, a functional test of the control/protection circuits should be performed. The test includes the verifying the fire detectors initiate the appropriate protection function and alarms. This test should include verification that the unit differential relay would initiate CO_2 discharge.]	**[Annually]**	FIST 5-12 Section 9.2 PEB 55 Appendix 16
[An annual visual inspection as described below will be performed on all types of batteries located within fire detection and alarm systems.] (1) Lead-acid batteries will be examined for signs of failure such as bulging, cracking, open vents, leaking electrolyte, and corrosion. (2) NiCad batteries will be examined for signs of damage, bulging, heating, corrosion, or leaking electrolyte.	**[Annually]**	PEB 55 Appendix 16
[A minimum 90-minute annual discharge test shall be performed to verify the proper operation of the fire detection systems.] This is typically performed by removing input power to the fixture and monitoring the performance of the system. During the 90-minute test, verify the fire detection system is fully operational for the duration of the test by monitoring the system display. This test can be performed through automated procedures.	**[Annually]**	PEB 55 Appendix 16

Maintenance Task	Frequency	Reference
A CO_2 system functional test should be performed simulating an actual fire using smoke bombs, local heaters, or other methods to test operation of the detectors and sensors. This test should be repeated every 5 years.	5 years	FIST 5-12 Section 9.2
Hydrostatic testing of the following types of extinguishers: storage-pressure water and/or antifreeze; wetting agent; foam; loaded stream; dry chemical extinguishers with stainless steel shells, or soldered-brass shells; CO_2.	5 years	FIST 5-12 Section 3.3.4
Stored pressure-dry chemical extinguishers that require a 12-year hydrostatic test will be emptied and subjected to applicable maintenance procedures every 6 years.	6 years	FIST 5-2 Section 3.3.3
HydroStatic testing of the following types of extinguishers: dry chemical, stored pressure, with mild steel shells, brazed-brass shells, or aluminum shell;. dry chemical, cartridge operated with mild steel shell; Bromotrifluoromethane Halon 1301; Bromochlorodifluoromethane Halon 1211; dry power, cartridge operated, with mild steel shells.	12 years	FIST 5-12 Section 3.3.4

2.23 Blackstart Generators

Maintenance Task	Frequency	Reference
{Test each blackstart unit to show that it can be started and operated without being connected to the system. Each black start unit shall be tested at least every 3 years.}	**{3 years}**	PEB 55 Appendix 17

A demonstration of blackstart capability through simulation or testing that shall be performed at least every 5 years.	5 years	PEB 55 Appendix 17

2.24 Engine Generators

Maintenance Task	Frequency	Reference
[Inspect all Emergency Power Supply System (EPSS) components comprising engine-generators and associated equipment such as automatic transfer switches.]	**[Weekly]**	PEB 28 PEB 55 Appendix 18
[Generator set battery is to be inspected and maintained in full compliance with manufacturer's recommendations weekly.]	**[Weekly]**	PEB 28 PEB 55 Appendix 18
[Engine generator sets are to be exercised for a minimum of 30 minutes monthly.]	**[Monthly]**	PEB 28 PEB 55 Appendix 18
[Engine generator transfer switch is to be operated electrically, both directions monthly.]	**[Monthly]**	PEB 28 PEB 55 Appendix 18
[Circuit breakers for engine generators are exercised manually each year.]	**[Annually]**	PEB 28 PEB 55 Appendix 18
[EPSS is to be operated at available load for assigned class duration or minimum of 4 hours every 2 years.]	**[2 years]**	PEB 28 PEB 55 Appendix 18

2.25 Generators and Large Motors (>500HP)

Maintenance Task	Frequency	Reference
[During plant rounds check commutation or collector ring and brush operation.] Wipe	**[Plant rounds]**	PEB 55 Appendix 19

Maintenance Task	Frequency	Reference
commutator or brush rings if needed. Have brushes replaced if worn too short.		
[During plant rounds check bearing temperatures, lubrication, and oil level. Check water leaks in bearing and cooling coils and surface air coolers. Check cooling water flow.]	**[Plant rounds]**	PEB 55 Appendix 19
AVR operation shall be reported monthly in accordance with the Western Electricity Coordinating Council (WECC) Reliability Management System (RMS) reporting procedures.	Monthly	PEB 55 Appendix 17
Report Power System Stabilizer (PSS) operation monthly in accordance with the WECC RMS reporting procedures.	Monthly	PEB 55 Appendix 17
Check electrical control circuits and indicating lights. Weigh all CO_2 cylinders and replace cylinders in which the CO_2 content weighs less than 90 percent of the weight marked on the cylinder by the supplier.	Monthly	FIST 4-1A Section 2.11.1-13
[Generator thrust-bearing insulation and oil film resistance – Bearing insulation test should be performed annually on all Reclamation generators.]	**[Annually]**	FIST 3-11 FIST 4-1A Section 2.11.1-8 PEB 55 Appendix 19
Periodic tests of insulation resistance – A standard schedule should be worked out which provides for measuring the insulation resistance of each motor at least once a year. In addition, those motors which have been idle for long periods, especially those in humid atmosphere, should be measured before starting lest the windings burn out when starting up. Tests have shown this to be possible after short exposure to	Annually	FIST 3-4 Section 2.2

Maintenance Task	Frequency	Reference
100 percent relative humidity, whether the motor is fully enclosed or open type. It is preferred that annual resistance measurements be taken at existing room temperature.		
Thoroughly inspect stress carrying parts of rotor for cracks. Check bolted connections for tightness and any evidence of movement. Check stator frame for loose connections, cracks, or other damage. Check stator air gap at a minimum of four positions, top, and bottom.	Annually	FIST 4-1A Section 2.11.1-10
On-line partial discharge test.	Testing should be repeated every 6 to 12 months for online partial discharge monitoring. If deterioration is detected during online testing, monitoring intervals should be reduced to every 3 to 6 months.	PEB 29 Page 33
[Conduct insulation resistance (Megger) and dielectric absorption test (PI) to identify factors in assessing serviceability of generator or large motor armature and/or field winding insulation every 5 years.]	**[5 years]**	PEB 29 Page 24 PEB 55 Appendix 19
[The DC, high-voltage test is believed to give a practical indication of the electrical quality of the insulation at the time of the test. Once satisfactory benchmark data on a machine have been established, the interval between tests is 5 years unless an abnormality is indicated or suspected.]	**[5 years]**	FIST 3-1 Section 39 PEB 29 PEB 55 Appendix 19
AVR equipment shall be tested and calibrated in conjunction with the balance of the excitation system as often as necessary to maintain calibration/	5 years	PEB 55 Appendix 17

Maintenance Task	Frequency	Reference
performance, but at least once every 5 years or following any repairs to the excitation system.		
Test and calibrate PSS equipment in conjunction with AVR testing and calibration.	5 years	PEB 55 Appendix 17

2.26 Governors

Maintenance Task	Frequency	Reference
Permanent Magnet Generator (PMG) or Speed Signal Generator (SSG) annual adjustments: Inspect the speed switches and drive gears for wear. Lubricate pivot pins and check speed switch bearings. Check the setting and operation of the speed switches. Check the insulation between PMG or SSG housing and the supporting frame by measuring the resistance from the housing to ground with a Megger. Replace or repair the insulating gasket as required. Check the voltage output of the PMG.	Annually	FIST 2-3 Section 8.14
Position and limit switches annual adjustments: Check the operation and settings of the gate limit, the speed changer position, and the gate position switches and adjust as required. Clean the contacts as required. Check the drive gears for wear and proper meshing. Check annunciation where applicable.	Annually	FIST 2-3 Section 8.15
[Shutdown solenoids annual adjustments: Check the operation of the solenoids for binding or sticking when tripped and reset. Check the settings to ensure that the complete shutdown solenoid closes the wicket gates completely and the partial	**[Annually]**	FIST 2-3 Section 8.16 PEB 55 Appendix 20

Maintenance Task	Frequency	Reference
shutdown solenoid brings the gates to the speed no load setting. When the solenoids are reset, make sure that the linkage does not prevent the gates from going to 100 percent. Inspect the solenoid for any signs of overheating or other damage. Check the condition of electrical connections and auxiliary contacts.]		
Speed changer, gate limit motors, and remote position indicators annual adjustments: Operate motors and check for excessive vibration or noise. Replace bearings as required. Check electrical connections and motor brushes. Check the operation of the position indicators for any sticking or binding and check the correlation between the transmitter and receiver. Check gears for wear and proper meshing. Check the clutch adjustment.	Annually	FIST 2-3 Section 8.17
Check wicket gate timing and speed droop calibration.	Annually	FIST 2-3 Section 8.1
All governor adjustment tests: Wicket gate timing, PMG voltage and frequency, check and adjust permanent droop, adjust speed changer, adjust dashpot, check and adjust dither, normal operations check.	5 years	FIST 2-3 Section 8.1 PEB 55 Appendix 20

2.27 Motors (< 500 hp)

Maintenance Task	Frequency	Reference
[Periodic tests of insulation resistance – A standard schedule should be worked out which provides for measuring the insulation	**[Annually]**	FIST 3-4 Section 2.2 PEB 55 Appendix 21

Maintenance Task	Frequency	Reference
resistance of each motor at least once a year. In addition, those motors which have been idle for long periods, especially those in humid atmosphere, should be measured before starting lest the windings burn out when starting up. Tests have shown this to be possible after short exposure to 100 percent relative humidity, whether the motor is fully enclosed or open type. It is preferred that annual resistance measurements be taken at existing room temperature.]		

2.28 Personal Protective Equipment

Maintenance Task	Frequency	Reference
[In addition to inspection before each use, protective grounds and associated live-line tools used for their installation shall be given initial and annual electrical tests as follows: Ground cable assemblies, live-line tools including insulated gloves, and blankets and sleeves.]	**[Annually]**	FIST 5-1 Section 10.3 FIST 5-1 Section 10.4 PEB 55 Appendix 22
[Perform personal protective ground cable millivolt drop test annually to reveal if there is damage close to and within the pressed ferrule within the cable and also test the integrity of the clamps (loose or defective joints).]	**[Annually]**	PEB 29 Page 37 PEB 55 Appendix 22
[Electrical and electronic indicating type detectors shall be checked for functionality before and after each use.]	**[Annually]**	FIST 5-1 Section 6.5 PEB 55 Appendix 22
[Hotsticks shall be electrically	**[Annually]**	FIST 3-29 Appendix A

Maintenance Task	Frequency	Reference
tested in a shop or laboratory at least annually.]		PEB 55 Appendix 22

2.29 Potheads

Maintenance Task	Frequency	Reference
For PM purposes, it is recommended that a thermal analysis survey be performed annually on cables, potheads, and stress cones.	Annually	FIST 4-13 Section 6.3.1
[Annually, inspect the potheads for cracking of any filler or compound, separation from the cable, or evidence of movement between the pothead and cable insulation, evidence of tracking or corona powder, or any oil leaks if the cable is oil filled.]	**[Annually]**	PEB 55 Appendix 23
[Routine tests of cables are to be conducted at intervals of 5 years. "Hot-collar" power-factor tests on cable potheads are useful, sensitive indications of moisture and voids or other substandard conditions in the potheads.]	**[5 years]**	FIST 3-1 Section 49 FIST 3-1 Section 55 PEB 55 Appendix 23

2.30 Electromechanical Relays and Protection Circuits

Maintenance Task	Frequency	Reference
[Electromechanical relays calibration and functional testing.] Check to see that all connections are tight. Loose connections could indicate excessive vibration that must be corrected. Check to ensure that rotating discs rotate freely. All gaps must be checked to ensure that they are free of foreign	**[Every year thereafter in harsh conditions and every 2 years in controlled environments.]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 12.1

Maintenance Task	Frequency	Reference
material. If foreign material is found, check the case gasket and replace it, if necessary. All contact or armature gaps must be inspected. Measure contacts for alignment and wipe. Checking bearings or pivots usually involves dismantling the relay. Manually close or open the contacts and observe that they perform their required function. Manually close or open the contacts and observe that they perform their required function. Reduce current or voltage until the relay resets. Observe the armature or disc movement. Auxiliary relays employing devices for time delay (for example, capacitors or air bellows) should have an operating time test performed (either pickup or dropout, whichever is applicable).		
[Fault/load study and check protection settings.]	**[5 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 4.1
[Verify that acceptable instrument transformer output signals are received at the protective relay.]	**[6 years]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1

2.31 Solid-State Relays and Protection Circuit

Maintenance Task	Frequency	Reference
[During plant rounds visual inspection will be performed to verify relay power indicating light is illuminated.] The check is intended to verify the relay has power and an operational power supply.	**Plant rounds**	PEB 55 Appendix 24
[Solid-state relays calibration and functional testing.] Check to see that connections are tight. The relay must be examined for excessive debris. Using a digital multimeter, check the input	**[2 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 13.1

voltage to the relay. If the relay has a dual power supply, ensure jumpers are in the correct position to provide the correct voltage. If so equipped, use the test function switch on the relay to ensure that all indicators are working correctly. Also, exercise the reset to ensure that this function is working. Gradually apply current or voltage to see that pickup is within limits. For timing tests, it is important to test the relay at multiple points on the timing curve. Many of the procedures for testing solid-state relays are the same as for testing electromechanical relays.		
[Verify that acceptable instrument transformer output signals are received at the protective relay.]	**[6 years]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1

2.32 Microprocessor Relays

Maintenance Task	Frequency	Reference
[During plant rounds visual inspection will be performed on unmonitored microprocessor based relays to check for relay trouble indication.] The visual inspection should include verifying the relay has power by examining the front panel and LEDs, and confirming the LEDs are illuminated. Status indication on the front panel should be read using front panel controls or via computer. Error or trouble codes should be documented and addressed as soon as possible.	**Plant rounds**	PEB 55 Appendix 25
[Microprocessor (digital) relay input and output verification.]	**[2 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 14.2 PEB 51 Table 1
[Microprocessor (digital) relays functional testing –	**[4 years]**	FIST 3-8 Section 3 Table 1

Unmonitored.] Check that the settings are correct (note any differences). The appropriate output contacts close/open at the proper time and under the appropriate inputs. Analog and digital outputs are accurate and reliable. Indicating devices, such as targets or indicating lights, operate correctly. Logic functions operate as designed.		FIST 3-8 Section 14.2
[Microprocessor (digital) relay setting verification and documentation.]	**[4 years (following relay testing or following a relay operation)]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1
[Microprocessor (digital) relays functional testing – Monitored.] Check that the settings are correct (note any differences). The appropriate output contacts close/open at the proper time and under the appropriate inputs. Analog and digital outputs are accurate and reliable. Indicating devices, such as targets or indicating lights, operate correctly. Logic functions operate as designed.	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 14.2
[Verify that acceptable instrument transformer output signals are received at the protective relay.]	**[6 years]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1

2.33 Communication Systems for Protective Relaying

Maintenance Task	Frequency	Reference
[Protection system communications equipment and channels required for correct operation of protection systems – Unmonitored.]	**[Quarterly]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1
[Protection system communications equipment and channels required for correct operation of protection systems – Monitored.]	**[6 years]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1

2.34 Lockout Relays

Maintenance Task	Frequency	Reference
[Check red light lit for lockout relay and circuit breaker coil continuity or real-time lockout and breaker trip coil continuity monitor and alarm.]	**[Daily, once per shift in staffed plants, and check every time the plant is visited at unstaffed plants.]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Sections 8, 9.4 PEB 51 Table 1
[Protective circuit functional testing, including lockout relay testing, must take place every 2 years.] Initiate a lockout relay trip with the protective relay contact. Prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Visually and/or electrically, verify that the lockout relay actually tripped from the protective relay action. Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Verify that every contact in the lockout relay actually has functioned properly. Activate the lockout relay from each protective device. After the first full test of the lockout relay and breakers, the lockout relay may be left in the trip position so as not to repeatedly trigger the lockout coil; a meter, light, buzzer, or existing amber light may be substituted to verify contact operation. Visually check that all alarms, meters, lights, and other indicators have activated. Perform a timing test on the lockout relays and trend data each time testing is performed. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit	**[2 years]**	FIST 3-8, Section 8 FIST 3-8, Section 9.2

Maintenance Task	Frequency	Reference
functional testing. Auxiliary relays may be a critical component of protection circuits, and it is important to include these relays when performing functional testing.		
[Sealed lockout relay timing test.]	**[2 years per PEB 51; 6 years per FIST 3-8]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1
[Non-sealed lockout relay timing test, cleaning, and lubrication. Note: Lockouts may not need to be oiled or cleaned; see manufacturer's instructions.]	**[2 years per PEB 51; 6 years per FIST 3-8]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1

2.35 Protection Circuits

Maintenance Task	Frequency	Reference
[Protection circuit functional test, between relay outputs and breaker input, including lockout relays.]	**[2 years]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1
[Protective circuit functional testing, including lockout relay testing, must take place every 2 years.] Initiate a lockout relay trip with the protective relay contact. Prove that a protective relay action actually will trip the lockout relay and that the lockout will trip circuit breakers or other protective devices (e.g., governor, exciter, etc.). Visually and/or electrically, verify that the lockout relay actually tripped from the protective relay action. Verify that circuit breakers actually tripped (or other protective action occurred) from the lockout relay action. Verify that every contact in the lockout relay actually has functioned properly. Activate the lockout relay from each protective	**[2 years]**	FIST 3-8 Section 8 FIST 3-8 Section 9.2

Maintenance Task	Frequency	Reference
device. After the first full test of the lockout relay and breakers, the lockout relay may be left in the trip position so as not to repeatedly trigger the lockout coil; a meter, light, buzzer, or existing amber light may be substituted to verify contact operation. Visually check that all alarms, meters, lights, and other indicators have activated. Perform a timing test on the lockout relays and trend data each time testing is performed. Additional breaker control circuitry, such as breaker failure, reclosing, and transfer trip schemes, need to be included as part of the lockout circuit functional testing. Auxiliary relays may be a critical component of protection circuits, and it is important to include these relays when performing functional testing.		
[Functionally test all ICS control, protection, and alarm circuits, including all control-related, protection-related, alarm-related, and other critical inputs and outputs and all status inputs, upon commissioning and every 2 years thereafter.]	**[2 years]**	FIST 3-33 Section 7.1.2.2

2.36 SCADA Systems and Voice Communication

Maintenance Task	Frequency	Reference
[Test radio, telephone, satellite, and cellular systems used for voice communication monthly by establishing a voice contact, verifying clear reception, and logging the result.]	**[Monthly]**	PEB 55 Appendix 26
[In addition to the federally mandated testing of	**[Quarterly]**	PEB 55 Appendix 26

Maintenance Task	Frequency	Reference
transmission equipment utilizing licensed frequencies, unmonitored analog SCADA communication requires communication equipment testing as defined below upon commissioning, 0.25 years thereafter, and after equipment modifications.]		
Equipment power – UPS testing should be performed based on the manufacturer's requirements; or if no manufacturer's requirement is available, it should be tested annually.	Annually	FIST 3-33 Section 7.1.2.3 PEB 55 Appendix 26
Management – Effective ICS operations and maintenance programs depend on key management practices that include: (1) roles and responsibilities, (2) planning, and (3) monitoring. This "Management" section covers the general requirements for ICSs. It is important to note that the scope of the requirements varies with size and criticality of the ICS. [Business cases and maintenance plans must be developed and reviewed annually or as directed by policy.]	Annually	FIST 3-33 Section 5.2
{A business case for the ICS (e.g., see OMB Circular A-11, Exhibit 300) must be developed for the annual budget formulation and investment review process.}	**{Annually}**	FIST 3-33 Section 5.2.1
{Annual maintenance plans for ICS, including revisions and upgrades, shall be developed and then coordinated with plant operations and maintenance staff.}	**{Annually}**	FIST 3-33 Section 5.2.2
Monitoring of planned maintenance versus actual improvements is performed periodically and on an annual	Annually	FIST 3-33 Section 5.3

Maintenance Task	Frequency	Reference
cycle when business cases and maintenance plans are developed.		
Environmental controls and fire protection – The environmental controls for the ICS should be checked annually for proper operation and maintained per requirements set by the manufacturer.	Annually	FIST 3-33 Section 7.1.2.1
The operability of any fire protection system should be verified at least annually.	Annually	FIST 3-33 Section 7.1.2.1
Check critical alarm inputs annually.	Annually	FIST 3-33 Section 7.1.2.2
[The input power should be switched off, and the load on the UPS and the duration that load can be supported should be measured every three years.]	**[Annually]**	FIST 3-33 Section 7.1.2.3 PEB 55 Appendix 26
At least 90 percent of maintenance work identified and scheduled, as part of the maintenance plan, should be completed on an annual basis.	Annually	FIST 3-33 Section 7.3
Remedial actions for operations staff – **[ICS corrective procedures shall be reviewed at least annually.]**	**[Annually]**	FIST 3-33 Section 7.4.1
Training – The training requirements for each staff member should be reviewed annually.	Annually	FIST 3-33 Section 8.3
Training for existing staff should be reviewed yearly.	Annually	FIST 3-33 Section 8.3.1
ICS support staff programming and software engineering training – Training requirements should be reviewed on a yearly basis.	Annually	FIST 3-33 Section 8.3.2
System administrator training – Reviews of training requirements	Annually	FIST 3-33 Section 8.3.3

Maintenance Task	Frequency	Reference
for system administrators should be made yearly.		
[Annually check the enclosure to ensure it is in good overall condition. Look for signs of dust buildup on inlets and circuit components, heating, corrosion, or loose hardware.]	**[Annually]**	PEB 55 Appendix 26
Controls and applications – Generally, critical controls should be checked at least every other year.	2 years	FIST 3-33 Section 6.4
[Functionally test all ICS control, protection, and alarm circuits, including all control-related, protection-related, alarm-related, and other critical inputs and outputs and all status inputs every 2 years.]	**[2 years]**	FIST 3-33 Section 7.1.2.2 PEB 55 Appendix 26
Check all transducer inputs at least once every 3 to 5 years to verify accuracy.	3 to 5 years	FIST 3-33 Section 7.1.2.2
ICSs require proper interface to the powerplant to operate correctly. All transducers shall be functional, and calibration must be maintained. **[ICS transducers shall be calibrated and tested on a cycle every 3 years to verify accuracy.]**	**[3 years]**	FIST 3-33 Section 7.1.2.2 PEB 55 Appendix 26
[In addition to the federally mandated testing of transmission equipment utilizing licensed frequencies, monitored SCADA communication requires communication equipment testing as defined below upon commissioning, 5 years thereafter, and after equipment modifications.]	**[5 years]**	PEB 55 Appendix 26

2.37 Switches, Disconnect

Maintenance Task	Frequency	Reference
[Visual inspection semi-annually or after a switch has carried heavy short-circuit current – Perform a visual inspection of the visible components of the disconnect switch.] Insulating members – Check the overall cleanliness; check for tracking; inspect for cracked or broken segments. Conductor and contact connections – Check for signs of looseness of connectors; check for signs of heating; check for evidence of corrosion; insure linkages and operating rods have not bent or distorted. Mechanical linkages and operating rods – Insure linkages and operating rods have not been bent or distorted; insure all fastenings (bolts, nuts, etc.) are secure; verify simultaneous closing of all blades; verify complete contact closing and opening. Equipment grounds – Verify ground connections are secure; verify ground strap flexible braids are not showing signs of corrosion, wear, or broken strands; verify ground conductor is secure and not touching other objects except where mounted. Interrupting device (if equipped) – Check condition of tank and levels. Motor operator (if equipped) – Check condition of enclosure; check for moisture; check for proper operation of space heaters; check the overall cleanliness of enclosure. Fuse (if equipped) – Check fuse that it is securely seated in clips; check fuse clip surfaces for pitting, heating, and alignment; check fuse tube for cleanliness and signs of deterioration; check that	**[6 months]**	PEB 46

Maintenance Task	Frequency	Reference
bolts and nuts are secure.		
[Annually – Verify proper operation of disconnect switch.] Insure linkages and operating rods have not been bent or distorted, check safety interlocks for proper operation, verify simultaneous closing of all blades, inspect contacts and arcing horn for burns or pitting, verify complete switch opening and closing, and verify the switch is mechanically locked in the close position.	**[Annually]**	PEB 46
[An IR scan must be performed annually.]	**[Annually]**	PEB 46
[Review the nameplate ratings of the disconnect switch every 5 years to insure this device is rated appropriately.]	**[5 years]**	PEB 46
[Every 3 years for outdoor installation and every 6 years for indoor installation – Perform major preventive maintenance on the disconnect switch.] The blades should be operated several times to see that they are properly aligned to engage contacts and are properly seated when closed. Contact surfaces should be inspected and cleaned or replaced if burned, pitted, or corroded. Insulation surfaces should be inspected and cleaned if necessary. Moving parts should be checked for proper operation and lubrications. Grounding conductors should be inspected and replaced if necessary, and safety interlocks should be inspected and tested for proper operation.	**[3 years; 6 years for indoor installation]**	PEB 46

2.38 Switchyard/Substation Ground Connections

Maintenance Task	Frequency	Reference
[Annually perform visual inspection to see that structure and apparatus ground leads are not loose or broken. Check and tighten connectors and clamps in ground leads. Check ground leads to a point at least a foot below ground line to see that they are not broken or corroding.]	**[Annually]**	PEB 55 Appendix 27
[Ground mats will be tested to verify their intended design and adequacy once every 6 years.]	**[6 years]**	PEB 55 Appendix 27

2.39 Switchyards, Substations, and Transmission Lines

Maintenance Task	Frequency	Reference
[Every 6 months check switchyards or substations: (1) For anything unusual on the premises. See that gates, buildings, switches, etc., are locked where necessary to prevent unauthorized persons from entering or tampering with equipment. (2) For oil leaks in storage tanks. Note amount of oil on hand and see that receiving tank is maintained empty when not in actual use for draining oil from transformers or breakers in an emergency. (3) Valves on active storage tanks, which can be operated without a wrench are plugged or locked closed. Drain condensate from storage tank sump. Repaint tanks and piping if necessary. Check	**[6 months]**	PEB 55 Appendix 28

Maintenance Task	Frequency	Reference
operation of oil pumps. Check hoses and other accessories used in draining or refilling apparatus tanks. **(4) Power is available on all essential power, lighting, and control circuits.** **(5) Fuses or circuit breakers on power, lighting, and control circuits. Check and tighten wiring connections at terminal points. Inspect wiring for open circuits, short circuits, and damaged insulation. Check insulation resistance of wiring with devices connected.]**		
[Every 6 months make from-the-ground check of transmission wood poles for signs of decay, misalignment, and damage from lightning or other causes. Check cross arms for splitting.]	**[6 months]**	PEB 55 Appendix 28
[Every 6 months for steel towers make from-the-ground check of structure for signs of rusting or loose or damaged members. Check condition of footings and anchors particularly in locations subject to soil erosion, movement, or settling. Treat corrosion with inhibitor. Make from-the-ground check to detect loose or broken pole down leads, or broken or corroded ground connections. Tighten clamps on ground connections. Inspect counterpoise conductors at intervals for corrosion and poor connections. This is particularly important in corrosive soil. Check resistance of ground connection.]	**[6 months]**	PEB 55 Appendix 28
[Every 6 months make from-the-ground inspection of main conductors and overhear	**[6 months]**	PEB 55 Appendix 28

Maintenance Task	Frequency	Reference
ground wires with field glasses to detect broken strands, incorrect sag, and clearances, etc. Inspect splices with field glasses to detect failure. Make from-the-ground inspection of hardware to detect loose bolts, pins, etc. Make from-the-ground inspection of condition of insulators to detect broken skirts and excessive dirt.]		
[Every 6 months check for anything unusual in the transmission right-of-way, such as accumulation of vegetation or dry materials around base of poles which might result in fire damage or make contact with the main conductors.]	**[6 months]**	PEB 55 Appendix 28
[Annually check switchyards or substations fence and gates for damage or openings through which animals or unauthorized persons might enter. Check fence ground connections. Cut weeds and grass as necessary, and apply weed killers where found to be effective. Repair eroded soil banks, retaining walls, roads, and walks. Clean tip and remove rubbish. Check danger signs on fence and gates.]	**[Annually]**	PEB 55 Appendix 28
[Perform transmission line maintenance routine patrol once a year of all transmission line rights-of-way.]	**[Annually]**	PEB 55 Appendix 28

2.40 Thermographic Maintenance (IR Scanning)

Maintenance Task	Frequency	Reference
Thermal analysis survey be performed annually – Arresters; batteries, connections, and battery chargers; buswork, ducts, enclosures, and insulators; bushings; cables, potheads, and stress cones; circuit breakers; coupling capacitors; current transformers; distribution panels; electrical connections; exciters and voltage regulators; fuses; generator components, as needed; lighting; motors and lead boxes; potential transformers; switches (disconnect); switchgear; power transformers; and transmission lines.	Annually	FIST 4-13 Section 6.3.1
Annual PM IR inspections.	Annually	FIST 4-13 Section 6.2
[An IR scan must be performed annually on disconnect switches.] The IR scan should be looking for hot spots especially at connector and contact points which could be a sign of a poor connection.	**[Annually]**	PEB 46
Scheduling of IR surveys – Each major station should be tested to detect hotspots in electrical connections and equipment is an important facet of an effective IR testing program every 2 or 3 years.	2 to 3 years	FIST 4-13 Section 7.4.3
Following the initial certification, the thermographer should be recertified on a 3 to 5-year basis.	3 to 5 years	FIST 4-13 Section 4.6
Scheduling of IR surveys – Less important stations should be tested to detect hotspots in electrical connections and equipment is an important facet of an effective IR testing	3 to 4 Years	FIST 4-13 Section 7.4.3

Maintenance Task	Frequency	Reference
program every 3 to 4 years.		
Thermal analysis survey be performed annually – Arresters; batteries, connections, and battery chargers; buswork, ducts, enclosures, and insulators; bushings; cables, potheads, and stress cones; circuit breakers; coupling capacitors; current transformers; distribution panels; electrical connections; exciters and voltage regulators; fuses; generator components, as needed; lighting; motors and lead boxes; potential transformers; switches (disconnect); switchgear; power transformers; and transmission lines.	Annually	FIST 4-13 Section 6.3.1

2.41 Transducers/Meters/Switches

Maintenance Task	Frequency	Reference
For electric traction elevators – Check and adjust car door operation. Lubricate hangers, rollers, gibs, linkages, and pivot points. Check and adjust door clearances, eccentrics, arm bearings, speed control switches, cables, clutches, chains, and belts. Check the operation of the limit and safety switches in hoistway and car.	Monthly	FIST 2-10 Appendix B
For hydraulic elevators – Check and adjust door clearances, eccentrics, arm bearings, speed control switches, cables, clutches, chains, and belts. Check the operation of limit and safety switches in hoistway and in/on the car.	Monthly	FIST 2-10 Appendix C
Standby power system transfer switch operated electrically, both directions.	Monthly	PEB 28

Maintenance Task	Frequency	Reference
For electric traction elevators – Check and clean the door switch contacts. Check the door speed control switches.	Quarterly	FIST 2-10 Appendix B
For hydraulic elevators – Check and clean the door switch contacts. Check the door speed control switches.	Quarterly	FIST 2-10 Appendix C
For electric traction elevators – Test all of the terminal limit switches. Lubricate the limit switch roller pins.	Semi-annually	FIST 2-10 Appendix B
Governor position and limit switches – Check the operation and settings of the gate limit, the speed changer position, and the gate position switches and adjust as required. Clean the contacts as required. Check the drive gears for wear and proper meshing. Check annunciation where applicable.	Annually	FIST 2-3 Section 8.15
Governor speed changer, gate limit motors, and remote position indicators – Check the operation of the position indicators for any sticking or binding and check the correlation between the transmitter and receiver.	Annually	FIST 2-3 Section 8.17
[ICS transducers shall be calibrated and tested on a cycle every 3 years to verify accuracy.]	**[3 years]**	FIST 3-33 Section 7.1.2.2 PEB 55 Appendix 26
All transducer inputs be checked at least once every 3 to 5 years to verify accuracy.	3 to 5 years	FIST 3-33 Section 7.1.2.2

2.42 Current Transformers (CT), Potential Transformers (PT), and Coupling Capacitors

Maintenance Task	Frequency	Reference
[Annually de-energize CCVT's and make close visual inspection for bulged case, chipped or cracked bushings, loose connections, and for oil leaks. Check oil level of the basebox by means of the oil gauge.] Clean bushings.	**[Annually]**	PEB 55 Appendix 10
[Instrument transformers, used for protective relaying, must have burdens measured every 6 years.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.1 PEB 51
[Current transformer excitation test.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.1
[Insulation resistance tests.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.3 PEB 51 Table 1
[The CT and PT secondary circuits must be grounded at only one point, and secondary grounding must be verified at least every 6 years.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.3
[Verify that acceptable instrument transformer output signals (magnitude and phasing) are received at the protective relay every 6 years.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.2 PEB 51 Table 1
[Instrument transformer secondary circuit polarity, phasing, and connections testing.]	**[6 years; deleted from routine testing by PEB 51]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.4

2.43 Dry-Type Power Transformers

Maintenance Task	Frequency	Reference
[Once each year under normal load, check transformer temperatures with an IR camera [4,7]. If the temperature rise (above ambient) is near or above nameplate rating, check for overloading. Check the temperature alarm for proper operation. Check enclosures and vaults/rooms for dirt accumulation on transformer surfaces and debris near or against enclosures. Remove all items near enough to affect air circulation. To avoid dust clouds, a vacuum should first be used to remove excess dirt. Low pressure (20 to 25 pounds per square inch [psi]) dry compressed air may be used for cleaning after most dirt has been removed by vacuum. The transformer must be de-energized before this procedure unless it is totally enclosed and there are no exposed energized conductors. Portable generators may be used for lighting. **After de-energizing the transformer, remove access panels and inspect windings for dirt- and heat-discolored insulation and structure problems [14]. It is important that dirt not be allowed to accumulate on windings because it impedes heat removal and reduces winding life. A vacuum should be used for the initial winding cleaning, followed by compressed air [7]. Care must be taken to ensure the compressed air is dry to avoid blowing moisture into windings. Air pressure**	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29

Maintenance Task	Frequency	Reference
should not be greater than 20 to 25 psi to avoid imbedding small particles into insulation. After cleaning, look for discolored copper and insulation, which indicates overheating. If discoloration is found, check for loose connections. If there are no loose connections, check the cooling paths very carefully and check for overloading after the transformer has been re-energized. Look for carbon tracking and cracked, chipped, or loose insulators. Look for and repair loose clamps, coil spacers, deteriorated barriers, and corroded or loose connections. **Check fans for proper operation including controls, temperature switches, and alarms. Clean fan blades and filters if needed. A dirty fan blade or filter reduces cooling air flow over the windings and reduces service life. If ventilation ports do not have filters, they may be fabricated from home-furnace filter material. Adding filters is only necessary if the windings are dirty upon yearly inspections.]**		
[When the transformer is new, before energizing, and every 5 years, the transformer and bushings should be Doble tested.]	**[5 years]**	FIST 3-30 Section 4.7 PEB 29 PEB 55 Appendix 29

2.44 Oil-Filled Power Transformers

Maintenance Task	Frequency	Reference
[After 1 month of service and once each year, make an in-depth inspection of oil-filled transformers. Look carefully	**[Annually]**	FIST 3-30 Section 4.1 PEB 55 Appendix 30

Maintenance Task	Frequency	Reference
at temperature and oil level data sheets for a lack of variation in temperature, pressure, or oil level gages, even with seasonal temperature and loading changes. Examine the DGA test results for signs of moisture in the oil. Check transformer tank for excessive corrosion and oil leaks; check the top oil thermometers for leaks; and examine the winding temperature thermometers carefully at the capillary tubing between the thermometer well and dial indicator, if the tubing has been pinched or accidently struck, or a leak in the tubing system.]		
[Weekly check the bushing oil level by viewing the oil-sight glass or the oil level gage.]	**[Quarterly]**	FIST 3-30 Section 4.1.8 PEB 55 Appendix 30
[After 1 month of service and every quarter, check the external porcelain for cracks and/or contamination. Look carefully for oil leaks.]	**[Annually]**	FIST 3-30 Section 4.1.8 PEB 55 Appendix 30
[After 1 month of service and yearly, inspect water-oil heat exchangers. Test and inspect the pumps. Look for and repair leaks in piping and heat exchanger body. Examine the latest DGA results for dissolved moisture and free water.]	**[Annually]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[After 1 month of service and yearly, check the oil flow indicator. With control power on the switch, open the pump circuit at the motor starter and make sure the correct alarm point activates when the pump stops. Check that the pointer is in the right position when the pump is off and when it is running.]	**[Annually]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30

Maintenance Task	Frequency	Reference
[After 1 month of service and yearly, inspect and test the oil pumps. Inspect piping and connections for leaks. Override the temperature controller so that the pump starts. Check the oil pump motor current on all three phases with an accurate ammeter; this will give an indication if oil flow is correct and if unusual wear is causing additional motor loading. Record this information for later comparison, especially if there is no oil flow indicator. Carefully inspect all valves to make sure they are fully open. Listen for unusual noises.]	**[Annually]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Cooling system inspections. After 1 month of service and yearly, inspect and test the fans. During an inspection, the temperature controller should be adjusted to start all the fans.]	**[Annually]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Once each year, and more often if a problem is encountered, do a DGA. DGA is unreliable if the transformer is de-energized and has cooled, if the transformer is new, or if it has had less than 1 to 2 weeks of continuous service after oil processing.]	**[Annually]**	FIST 3-30 Section 3.1 Table FIST 3-30 Section 4.4 PEB 29 PEB 55 Appendix 31
IR scan of transformer cooling system, bushings, and all wiring.	Annually	FIST 3-30 Section 3.1 Table
Test all controls, relays, gages; test alarms; and annunciator points.	Annually	FIST 3-30 Section 3.1 Table
Inspect pressure relief for leaks and indication for operation.	Annually	FIST 3-30, Section 4.1.5
Transformer bushings; testing and maintenance of high-voltage bushings – Examine the bushings with an IR camera [4,7]. If one phase shows a	Annually	FIST 3-30 Section 4.1.8

Maintenance Task	Frequency	Reference
markedly higher temperature.		
Once each year, check the pressure gage against the weekly data sheets.	Annually	FIST 3-30 Section 4.2
Gas pressure control components – Inspect the gas pressure control components.	Annually	FIST 3-30 Section 4.2.2
[Every 5 years (if the conservator has a diaphragm), remove the conservator inspection flange and look inside with a flashlight.]	**[5 years]**	FIST 3-30 Section 4.2 PEB 55 Appendix 31
[Thermometers should be removed and tested every 3 to 5 years to ensure the alarms work, and other functions should also be tested to see if the correct annunciator points activate, pumps/fans operate, etc.]	**[5 years]**	FIST 3-30 Section 4.1.3 PEB 55 Appendix 31
[Every 5 years, check the tank oil level indicators and alarm/tripping circuits should also be tested to see if the correct annunciator points and relays respond.]	**[5 years]**	FIST 3-30 Section 4.1.4 PEB 55 Appendix 31
[Every 5 years examine the pressure relief device for leaks at the gaskets.]	**[5 years]**	FIST 3-30 Section 4.1.5 PEB 55 Appendix 31
[Once every 5 years, the sudden pressure relay should be tested including the electrical functions. Disconnect the tripping circuit and use an ohmmeter to test for relay operation. Test the alarm circuit and verify that the correct alarm point is activated. Use an ohmmeter to verify the trip signal is activated or, if possible, apply only control voltage to the breaker and make sure the tripping function operates.]	**[5 years]**	FIST 3-30 Section 4.1.6 PEB 55 Appendix 31
[Once every 5 years while the	**[5 years]**	FIST 3-30 Section 4.1.7

Maintenance Task	Frequency	Reference
transformer is de-energized, functionally test the Buchholz relay by pumping a small amount of air into the top chamber with a squeeze bulb hand pump. Watch the float operation through the window. Check to make sure the correct alarm point has been activated. On some relays, a rod is provided so that you can test both bottom and top sections by pushing the floats down until the trip points are activated. If possible, verify that the breaker will trip with this operation. A volt-ohmmeter may also be used to check the switches.]		PEB 55 Appendix 31
[Transformer bushings; Testing and maintenance of high-voltage bushings – Once every 5 years, a close physical inspection and cleaning should be done [9]. Check carefully for leaks, cracks, and carbon tracking.]	**[5 years]**	FIST 3-30 Section 4.1.8 PEB 55 Appendix 31
[Transformer Bushings; Testing and maintenance of high-voltage bushings – Once every 5 years, depending on the atmosphere and service conditions, the bushings should be Doble tested.]	**[5 years]**	FIST 3-30 Section 4.1.8 PEB 29 PEB 55 Appendix 31
[When the transformer is new before energizing and every 5 years, the transformer and bushings should be Doble tested.]	**[5 years]**	FIST 3-30 Section 4.7 PEB 29 PEB 55 Appendix 31

2.45 Transformer Fire Suppression Systems

Maintenance Task	Frequency	Reference
[Annually, each transformer fire suppression system should be tested functionally	**[Annually]**	FIST 3-32 Section 10 PEB 55 Appendix 32

to ensure that: **• Detecting and initiating devices de-energize the transformer.** **• Detecting and initiating devices trigger a fire water release.** **• All components of the control circuitry operate correctly.** **• Motors, pumps, solenoids, and valves operate correctly.** **• Water is delivered to the discharge nozzles.** **• Nozzles are free of debris.** **• Containment system drain valves operate correctly.** **• Sump pumps are deactivated.** **• All alarms and indication function properly.]**		
Oil spill cleanup – Training must be provided to O&M staff on a recurring (annual) basis.	Annually	FIST 3-30 Section 13

2.46 Calibration of Test Equipment

Maintenance Task	Frequency	Reference
[Accurate voltmeters are critical for extending battery life. Provide a digital voltmeter accurate to 0.01V reserved only for station battery duty and calibrate it or send it out for calibration at least once a year.]	**[Annually]**	FIST 3-6 Section 1.4 PEB 55 Appendix 33
[An IR camera may be used for temperatures; however, the camera calibration must be checked at least once each year.]	**[Annually]**	FIST 3-6 Section 1.5 PEB 55 Appendix 33
[Annually calibrated test equipment that is used to check the calibration or proper operation of other equipment. Calibration is required annually for equipment used	**[Annually]**	PEB 55 Appendix 33

to take measurements for test results to show compliance with regulatory requirements.]		