BUREAU OF RECLAMATION

Facilities Instructions, Standards and Techniques Volume 4-1B

Maintenance Scheduling for Electrical Equipment

(FIST 014) 01/10/2019
U.S. Department of the Interior SUPERSEDES FIST TRMR-101 (FIST 010) 01/05/2018
(Minor revisions 06/05/2020, 07/27/2020, 09/27/2021, 08/01/2022)

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14. ABSTRACT
This document provides the existing tasks and frequencies for periodic maintenance of electrical equipment in Bureau of Reclamation facilities. 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
EHV	Extra High Voltage
FIST	Facilities Instructions, Standards, and Techniques
HECP	Hazardous Energy Control Program
hipot	high potential tests
IEEE™	Institute of Electrical and Electronics Engineers
IR	infrared
ICS	Industrial Control Systems
kV	kilovolt
MCCB	Molded case circuit breaker
NERC	North American Electrical Reliability Corporation
NiCd	Nickel Cadmium
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
PEB	Power Equipment Bulletin
PM	Preventive Maintenance
PMG	Permanent magnet generator
PO&M	Power Operation and Maintenance
PRO	Power Resources Office
PSMP	Protection System Maintenance Program
PSS	power system stabilizer
RCM	reliability centered maintenance
RSHS	Reclamation Safety and Health Standards
SCADA	Supervisory Control and Data Acquisition

SSG	Speed signal generator
SF_6	Sulphur Hexaflouride
SO_2	Sulphur dioxide
SOF_2	Thionyl Flouride
TSC	Technical Service Center
V	volt
VLA	Vented Lead Acid
VRLA	Valve Regulated Lead Acid
XLPE	Cross (X) Linked Polyethylene

1.0 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 or other approved asset management tools for non-power facilities. 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 this FIST supersedes the referenced FIST or PEB. 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 manufacturers' 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 Safety activities must be conducted in accordance with FIST Standards 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.]** See Section 1.6 for the definition of black, bold bracketed tasks.

1.3.1 Maintenance Frequencies

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.

- Plant Rounds: During plant checks, either per shift for manned facilities, weekly for un-manned facilities.
- Daily: Working weekdays only
- 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. Refer to CARMA Business Standards, CARMA 3.2 Preventative Maintenance Program for recommended tolerances.

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."

1.3.2 Maintenance and Testing of Critical Equipment

This standard defines critical equipment as any system, asset, or component whose failure could cause:

1. A loss of ability to convey water or the shutdown or load reduction of power generation
2. Loss of transmission capability or reduction in capacity
3. Serious personnel injury or violation of a safety regulation
4. An environmental hazard resulting in harm to the public, environment, or damage to public property.

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

FIST manuals are designed to provide guidance for maintenance and testing on equipment in Reclamation's facilities. There may be multiple ways to accomplish tasks outlined in this document. Facilities may exercise discretion as to how to accomplish certain tasks based on equipment configurations and available resources.

Reclamation's regions, PRO, and TSC agree that certain practices are required to be consistent across all Reclamation facilities. Mandatory FIST procedures, practices, and schedules that appear in

{Red, bold, and bracketed} or **[Black, bold, and bracketed]** text are considered Reclamation requirements for the O&M of equipment in power facilities. RM D&S FAC 04-14, *Power Facilities Technical Documents*, describes the responsibilities required by text designations: **{Red, bold, and bracketed}**, **[Black, bold, and bracketed]**, and plain text, within this technical document. Refer to RM D&S FAC 04-14 for more details concerning technical documents.

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 this FIST supersedes the source.

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.

1.8 NERC Reference {N}* in Frequency Column

A red bold **{N}*** listed in the frequency column indicates that NERC qualified facilities can neither vary nor deviate from the requirement. A NERC Reliability Standard exists that is the upper bounds of the frequency. A red bold and bracketed maintenance task that has black bold bracketed frequency with red bold **{N}*** indicates that the maintenance task is a red bold bracketed task to be performed at NERC specified frequency only for NERC qualifying facilities but it is still a black, bold bracketed maintenance task to be performed at the FIST specified frequency for all facilities.

2.0 Alarms, Annunciators, and Monitoring

2.1 General

Annunciators and alarms provide essential plant condition status information to O&M personnel. Two aspects must be considered:

1. Correct operation of annunciator and alarm devices
2. Integrity of the annunciator and alarm circuits

2.2 Maintenance Schedule for Annunciators/Alarms

Maintenance Task	Frequency	Reference
[Test the annunciator or alarm circuits by pressing a "Test" button which initiates all annunciator windows and sounds the audible alarm. **Verify that the expected audible alarms are heard and that all applicable indicating lights are lit.]**	**[Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	PEB 43
[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 manned plants or once per visit in unmanned plants)]**	FIST 3-8 Table 1 FIST 3-8 Section 9.4
{Functionally test all annunciator and alarm circuits, including wiring, and connections from beginning to end to ensure integrity of the total circuit}	**[2 years] {N}***	PEB 43 PSMP

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

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3.0 Surge Arresters

3.1 General

Lightning or surge arresters provide protection for important equipment from high energy surges. These arresters are static devices that require fairly infrequent maintenance. Most maintenance must take place while the associated circuit is de-energized. However, crucial visual inspections and infrared (IR) scans can take place while energized.

3.2 Maintenance Schedule for Arresters

Maintenance Task	Frequency	Reference
[Perform visual inspections by looking for any chips, cracks, or broken porcelain that the porcelain is clean, and verify the ground connection is secure.]	**[Outdoors: semiannually; Indoors: annually]**	PEB 44
Perform infrared inspections of energized arrestors	Annually	FIST 4-13 Section 6.3.1 FIST 3-31 Section 10.2
[Check tightness of line and ground connections.]	**[6 years]**	PEB 44
[Clean the porcelain surfaces, repair any damaged porcelain.]	**[6 years]**	PEB 44
[Check the apparent condition of the grounding conductors and their connections.]	**[6 years]**	PEB 44
[Check the condition of weatherheads and weatherhoods to determine that they remain in good condition.]	**[6 years]**	PEB 44
[Conduct insulation resistance tests and power factor tests.]	**[6 years]**	PEB 44 PEB 29, Page 43

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4.0 Batteries, Battery Chargers, and Battery Monitoring Systems

4.1 General

Battery systems provide "last resort" power for performing communication, alarm, control, and protective functions (relaying and breaker tripping) when other sources of power fail. Battery system maintenance should have highest priority. Computerized, online battery monitoring systems can be installed to supplement a maintenance program and reduce costs. Battery chargers require regular maintenance as well.

The O&M and testing requirements with the required interval as defined in the document are summarized in the table below.

4.2 Maintenance Schedule for Battery Safety

Maintenance Task	Frequency	Reference
[Ensure egress from the battery room is clear at all times.]	**[Plant Rounds]**	FIST 3-6 Section 2.8
[Verify the materials needed to mix a full gallon of neutralizing solution are available.]	**[Monthly]**	FIST 3-6 Section 2.4.4
[Operate non sealed eyewash station or portable eyewash equipment, as applicable.]	**[Monthly]**	FIST 3-6, Section 2.4.4
[Inspect sealed eyewash station for proper seal and that eyewash solution has not expired.]	**[Monthly]**	FIST 3-6, Section 2.4.4
[Check operation and cleanliness of emergency shower.]	**[Monthly]**	FIST 3-6 Section 2.4.4
[Verify unmonitored ventilation (airflow)	**[Monthly]**	FIST 3-6 Section 2.6.2

Maintenance Task	Frequency	Reference
devices (fans and vents) are operational.]		
{Perform a visual inspection of the battery, battery rack and associated equipment.}	**[Monthly] {N}***	FIST 3-6 Section 2.8.1 PSMP
[Perform visual inspection, including signage, checking for general cleanliness of the battery room, cabinets, availability of spill containment, neutralizing pillows, grounding straps, and other equipment located inside the battery room.]	**[Monthly]**	FIST 3-6 Section 2.8.1
[Check for the availability of a 10-pound class C dry chemical fire extinguisher and verify it has been inspected and tested according to schedule.]	**[Monthly]**	FIST 3-6 Section 2.8.1
[Check for availability and condition of insulated tools and utensils.]	**[Monthly]**	FIST 3-6 Section 2.8.1
[Check the hydrometer for cleanliness and lack of cracking of the rubber parts.]	**[Monthly]**	FIST 3-6 Section 2.8.1
[Check availability and condition of all safety equipment, such as gloves, aprons, face shields, goggles, etc.]	**[Monthly]**	FIST 3-6 Section 2.8.1

Maintenance Task	Frequency	Reference
[Perform visual inspection to ensure flame arrestors are properly installed and pores are clean.]	**[Quarterly]**	FIST 3-6, Section 2.5.1
[Verify that ventilation airflow monitoring and alarms are operational.]	**[Quarterly]**	FIST 3-6 Section 2.6.2
[Check ventilation airflow readings and compare to required airflow calculations.]	**[Annually]**	FIST 3-6 Section 2.6.2
IR Scan Batteries and connections and battery chargers	Annually	FIST 4-13 Section 6.3.1
{Provide adequate precautions to ensure that the facility has sufficient DC capability to safely control, protect, shut down, and isolate during an emergency condition or loss of station AC power.}	**Non-periodic:** **{Prior to isolating the station batteries}**	FIST 3-6 Section 4.6.2
{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.		

4.3 Maintenance Schedule for Vented Lead-Acid (VLA) Batteries

Maintenance Task	Frequency	Reference
{Document acceptable measurement ranges or percent variation for values recorded when performing maintenance activities listed below for VLA batteries.}	{Each maintenance interval}	FIST 3-6 Section 3.2
{Compare data collected at each maintenance interval to the baseline or previous results.}	{Each maintenance interval}	FIST 3-6 Section 3.5.1
[Check the voltmeter on the distribution panel to determine if the battery is being charged at the proper float voltage.]	[Plant rounds]	FIST 3-6 Section 3.5.2.2
{Verify no unintentional grounds on the battery system.}	[Plant rounds] {N}*	FIST 3-6 Section 3.5.9.1 PSMP
{Perform a visual inspection of the battery and associated equipment.}	[Monthly] {N}*	FIST 3-6 Section 3.5.6.1 PSMP
{Check the electrolyte level in every cell.}	[Monthly] {N}*	FIST 3-6 Section 3.5.6
{Check every cell for electrolyte leaks and cracks in cell jars.}	[Monthly] {N}*	FIST 3-6 Section 3.5.6
{Check condition of the vent plugs, flame arrestors, and dust caps.}	[Monthly] {N}*	FIST 3-6 Section 3.5.6
[Check the ambient temperature.]	[Monthly]	FIST 3-6 Section 3.5.6

Maintenance Task	Frequency	Reference
{Measure and record the overall float voltage with charger in service across the battery terminals.}	**[Quarterly] {N}***	FIST 3-6 Sections 3.5.2.2, and 3.6.2 PSMP
[Measure and record the float voltage on all individual cells to the nearest 0.01V with a digital voltmeter.]	**[Quarterly]** **Non-periodic:** **[Upon commissioning or upon complete disassembly and reassembly** **Whenever station service transformer taps are changed** **During equalizing charge** **When performing battery capacity test]**	FIST 3-6 Sections 3.5.2.1, 3.5.2.2, 3.6.2
[Measure and record specific gravity readings of all cells.]	**[Quarterly]** **Non-periodic:** **[After equalizing charge and 15 minutes after heavy gassing stops** **During equalizing charge** **Prior to performing battery capacity test]**	FIST 3-6 Sections 3.5.3.5, 3.5.3.6, and 3.6.2

Maintenance Task	Frequency	Reference
[Measure temperature readings of each individual cell in the system and record the results. Compare readings with the initial and all prior temperatures for trending purposes.]	**[Quarterly]** **Non-periodic: [After equalizing charge, about 15 minutes after heavy gassing stops** **During equalizing charge** **Prior to performing battery capacity test]**	FIST 3-6 Sections 3.5.4.1, 3.5.4.2, and 3.6.2
{Verify battery bank continuity.}	**[Quarterly] {N}***	FIST 3-6 Section 3.5.8.1 PSMP
[Using a micro-ohm meter, measure and record the resistance of each connection as a baseline (basis micro-ohms).]	**Non-periodic: [Upon commissioning or upon complete disassembly and reassembly]**	FIST 3-6 Sections 3.5.5.3
{Measure and record micro-ohm resistance values for all connections.}	**[Annually] {N}*** **Non-periodic: [Prior to performing battery capacity test]**	FIST 3-6 Sections 3.5.5.4 and 3.6.2 PSMP
[Document the sedimentation found within the batteries.]	**[Monthly]**	FIST 3-6 Section 3.5.6
{Perform battery capacity testing.}	**[5 years[1]] {N}*** **Non-periodic: {Upon commissioning}**	FIST 3-6 Sections 3.6 and 3.6.2 PSMP
[Apply an equalizing charge.]	**Non-periodic: [When necessary]**	FIST 3-6 Section 3.4.3
[Post a battery data card form POM-157 in a conspicuous location near the battery.]	**Non-periodic: [Upon installation, modification, or damage.]**	FIST 3-6 Section 3.5.1

Maintenance Task	Frequency	Reference
[Keep records of maintenance and connection resistance report.]	**[For life of equipment.]**	FIST 3-6 Section 3.5.1

[1] Perform battery capacity test each year if the capacity is less than 90% of the manufacturer's rated capacity, if the present capacity has decreased by more than 10% compared to the previous test, or if the battery has reached 85% of the battery's service life. Perform battery capacity test every 2 years if the battery has reached 85% of its service life (typically 20 years), but the tests indicate that the capacity is greater than 100% of the manufacturer's rated capacity.

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

4.4 Maintenance Schedule for Valve Regulated Lead-Acid (VRLA) Batteries (Gel Cell)

Maintenance Task	Frequency	Reference
{Document acceptable measurement ranges or percent variation for values recorded when performing maintenance activities listed below for VRLA batteries.}	**{Each maintenance interval}**	FIST 3-6 Section 4.2
{Compare data collected at each maintenance interval to the baseline or previous results.}	**{Each maintenance interval}**	FIST 3-6 Section 4.5.1
[Check the voltmeter on the control panel to determine if the battery is being charged at the proper voltage.]	**[Plant rounds]**	FIST 3-6 Section 4.5.2.2
{Verify no unintentional grounds on the battery system.}	**[Plant rounds]** **{N}***	FIST 3-6 Section 4.5.8.1 PSMP

Maintenance Task	Frequency	Reference
{Perform visual inspection of battery and associated equipment.}	**[Monthly] {N}***	FIST 3-6 Section 4.5.6.1 PSMP
{Check for electrolyte leaks and cover integrity, and take corrective action if needed.}	**[Monthly] {N}***	FIST 3-6 Section 4.5.6
[Check for corrosion at terminals and connectors.]	**[Monthly]**	FIST 3-6 Section 4.5.6
[Check the ambient temperature.]	**[Monthly]**	FIST 3-6 Section 4.5.6
{Measure and record the overall float voltage with charger in service across the battery terminals.}	**[Quarterly] {N}***	FIST 3-6 Section 4.5.2.2 PSMP
{Verify battery bank continuity.}	**[Quarterly] {N}***	FIST 3-6 Section 4.5.7.1 PSMP
[Measure and record the float voltage on all individual cells to the nearest 0.01V with a digital voltmeter.]	**[Quarterly]** **Non-periodic:** **[Upon commissioning or upon complete disassembly and reassembly** **24 hours after placing in float** **When the taps on the station service transformer are changed** **When performing battery capacity test]**	FIST 3-6 Sections 4.5.2.1, 4.5.2.2, and 4.6
[Measure temperature readings of each	**[Quarterly]**	FIST 3-6 Sections 4.5.3.1 and 4.5.3.2

Maintenance Task	Frequency	Reference
individual cell in the system and record the results.]	**Non-periodic: [24 hours after installation or complete disassemble and re-assemble, with system on a float and when the temperatures have stabilized]**	
{Measure and record the internal resistance on each cell.}	**[Quarterly] {N}*** **Non-periodic: [After installation or complete disassemble and re-assemble (1-3 days on float)]**	FIST 3-6 Sections 4.5.5.1 and 4.5.5.2 PSMP
[Measure and record resistance values for each connection between the cell post and the interconnection strap on the system.]	**Non-periodic: [Upon commissioning or upon complete disassembly and reassembly]**	FIST 3-6 Section 4.5.4.1
{Measure and record micro-ohm resistance values for all connections.}	**[Semi-annually] {N}*** **Non-periodic: [When performing battery capacity test]**	FIST 3-6 Sections 4.5.4.1, 4.5.4.2, and 4.6 PSMP
[Perform acceptance testing.]	**Non-periodic: [No sooner than 1 week after the battery has reached equilibrium in charge and temperature, but no later than 1 year after installation.]**	FIST 3-6 Sections 4.6.1 and 4.6.2
{Perform battery capacity test}	**[Annually[2]] {N}*** **Non-periodic: {Upon commissioning}**	FIST 3-6 Sections 4.6, 4.6.2.1, and 4.6.2.2 PSMP

Maintenance Task	Frequency	Reference
[Post a battery data card form POM-158 in a conspicuous location near the battery when battery is installed.]	**Non-periodic: [Upon installation, modification, or damage]**	FIST 3-6 Section 4.5.1
[Keep records of maintenance and connection resistance report.]	**[For life of equipment]**	FIST 3-6 Section 4.5.1

[2] Perform battery capacity test every year if the battery capacity is greater than 90% of the manufacturer's rated capacity. Every 6 months perform a capacity test, after the battery falls below 90% of the manufacturer's rated capacity during the annual capacity test. Replace the battery as soon as possible after it falls below 80% of its original capacity rating.

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

4.5 Maintenance Schedule for Vented (NiCd) Batteries

Maintenance Task	Frequency	Reference
{Document acceptable measurement ranges or percent variation for values recorded when performing maintenance activities listed below for NiCd batteries.}	**{Each maintenance interval}**	FIST 3-6 Section 5.2
{Compare data collected to the baseline or previous results.}	**{Each maintenance interval**	FIST 3-6 Section 5.5.1
[Check the voltmeter on the control panel to determine if the battery is being charged at the proper voltage.]	**[Plant rounds]**	FIST 3-6 Section 5.5.2.2

Maintenance Task	Frequency	Reference
{Verify no unintentional grounds on the battery system.}	[Plant rounds] {N}*	FIST 3-6 Section 5.5.9.1 PSMP
{Perform visual inspection of the battery and associated equipment.}	[Monthly] {N}*	FIST 3-6 Section 5.5.5.1 PSMP
{Check for electrolyte leaks and cracks in cells and take corrective action if found.}	[Monthly] {N}*	FIST 3-6 Section 5.5.5
[Check for corrosion at terminals and connectors.]	[Monthly]	FIST 3-6 Section 5.5.5
[Check the ambient temperature.]	[Monthly]	FIST 3-6 Section 5.5.5
{Check all the electrolyte levels.}	[Monthly] {N}*	FIST 3-6 Section 5.5.5
[Verify that the mineral oil level is approximately one-quarter inch.]	[Monthly]	FIST 3-6 Section 5.5.5
{Check condition of the vent plugs, flame arrestors, and dust caps.}	[Monthly] {N}*	FIST 3-6 Section 5.5.5
{Measure and record the overall float voltage with charger in service across the battery terminals.}	[Quarterly] {N}*	FIST 3-6 Section 5.5.2.2 PSMP
{Verify battery bank continuity.}	[Quarterly] {N}*	FIST 3-6 Section 5.5.8.1 PSMP

Maintenance Task	Frequency	Reference
[Measure and record the float voltage on all individual cells to the nearest 0.01 volts with a digital voltmeter.]	**[Quarterly]** **Non-periodic:** **[Upon commissioning or upon complete disassembly and reassembly** **During initial or equalizing charge** **When the taps on the station service transformer are changed** **When performing battery capacity test]**	FIST 3-6 Sections 5.5.2.1, 5.5.2.2
[Measure and record the electrolyte temperature of all cells.]	**[Annually]** **Non-periodic:** **[When performing battery capacity test]**	FIST 3-6 Section 5.5.3.1
{Measure and record micro-ohm resistance values for all connections.}	**[Annually] {N}*** **Non-periodic:** **[Upon commissioning or upon complete disassembly and reassembly** **When performing battery capacity test]**	FIST 3-6 Sections 5.5.4.1, 5.5.4.2 PSMP
[Perform acceptance testing]	**Non-periodic:** **[At the service location after the battery has been on a float charge for a minimum of 12 weeks without discharging]**	FIST 3-6 Section 5.6
{Perform battery capacity testing.}	**[5 years[3]] {N}*** **Non-periodic:** **[Upon commissioning]**	FIST 3-6 Sections 5.6.1, 5.6.2 PSMP

Maintenance Task	Frequency	Reference
[Post a battery data card from POM-159 in a conspicuous location near the battery.]	**Non-periodic: [Upon installation, modification, or damage]**	FIST 3-6 Section 5.5.1
[Keep records of maintenance and connection resistance report.]	**[For life of equipment]**	FIST 3-6 Section 5.5.1

[3] Perform battery capacity test every 5 years if capacity is greater than 90%. Perform battery capacity test each year if the capacity is less than 90% of the manufacturer's rated capacity. Replace battery as soon as possible after the capacity falls to 75%.

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

4.6 Maintenance Schedule for Battery Charging Equipment

Maintenance Task	Frequency	Reference
[Check the panel voltmeter to see if the correct float voltage for charging is being displayed.]	**[Plant rounds]**	FIST 3-6 Section 6.3.1
[For parallel chargers, check that each charger will carry the total plant load.]	**[Quarterly]**	FIST 3-6 Section 6.3.1
{Check the accuracy of the charger float voltage.}	**[Annually] {N}***	FIST 3-6 Section 6.3.1 PSMP
[Ensure float and equalize settings are correctly set.]	**[Annually]**	FIST 3-6 Section 6.3.1
[Check enclosures to verify they are clean and in good physical condition.]	**[Annually]**	FIST 3-6 Section 6.3.1

Maintenance Task	Frequency	Reference
[Check connection integrity.]	**[Annually]**	FIST 3-6 Section 6.3.1
[Verify and test associated alarms and settings.]	**[Annually]**	FIST 3-6 Section 6.3.1
[Ensure the maximum AC ripple voltage does not exceed manufacturer's specifications.]	**[Annually]**	FIST 3-6 Section 6.3.1

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

4.7 Maintenance Schedule for Automated Battery Monitoring Systems

Maintenance Task	Frequency	Reference
[Compare manual readings upon commissioning to values measured by the battery monitoring equipment.]	**Non-periodic: [Upon commissioning]**	FIST 3-6 Section 7.3.2.1
[Check the unit for any alarm indications and that the unit has power.]	**[Weekly]**	FIST 3-6 Section 7.3.2.2
[Review data recorded by the battery monitoring system]	**[Quarterly]**	FIST 3-6 Section 7.3.2.2
[Verify monitoring system battery float voltage.]	**[Annually]**	FIST 3-6 Section 7.3.2.2
[Verify monitoring system cell voltages to manual readings at the battery cells.]	**[Annually]**	FIST 3-6 Section 7.3.2.2

Maintenance Task	Frequency	Reference
[Verify monitoring system overall battery current.]	**[Annually]** **Non-periodic: [When performing battery capacity testing[4]]**	FIST 3-6 Section 7.3.2.2
[Verify monitoring system cell connection resistance.]	**[Annually]** **Non-periodic: [When performing battery capacity testing]**	FIST 3-6 Section 7.3.2.2
[Verify monitoring system cell temperature.]	**[Annually]** **Non-periodic: [When performing battery capacity testing]**	FIST 3-6 Section 7.3.2.2
[Verify monitoring system cell fluid levels, if applicable.]	**[Annually]** **Non-periodic: [When performing battery capacity testing, if applicable]**	FIST 3-6 Section 7.3.2.2
[Verify monitoring system cell specific gravity, if applicable.]	**[Annually]** **Non-periodic: [When performing battery capacity testing, if applicable]**	FIST 3-6 Section 7.3.2.2
[If your battery monitoring system includes additional functions not included in this list, compare these against manual measurements.]	**[Annually]**	FIST 3-6 Section 7.3.2.2

[4] Battery capacity tests should be performed every 5 years for flooded, lead-acid batteries with a capacity of greater than 90% and less than 20 years old.

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5.0 RESERVED

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6.0 Buswork, Enclosures, and Insulators

6.1 General

Buswork conducts current from one part of the powerplant or switchyard to another. Buswork usually is constructed of flat or round copper or aluminum busbar and can be either isolated-phase or nonsegregated. Except for infrared scanning, bus maintenance must be conducted de-energized. Standoff buswork insulators provide isolation of "live" power circuits from ground and other circuits. Failure of insulators will cause a power system fault and a forced outage.

6.2 Maintenance Schedule for Buswork, Enclosures, and Insulators

Maintenance Task	Frequency	Reference
IR Scan buswork, ducts, enclosures, insulators and grounds.	Annually	FIST 4-13 Section 6.3.1
[Check frame, panel, and cabinets for loose bolts, condition of paint, and cleanliness.]	**[5 years]**	PEB 47 Manufacturers' Maintenance guide
[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 Manufacturers' Maintenance guide
[Perform Insulation Test] (Power frequency dielectric loss, DC insulation resistance, power factor)	**[5 years]**	PEB 47 Manufacturers' Maintenance guide

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7.0 High Voltage Cables

7.1 General

Periodic maintenance tests are needed during the life of the cable to determine whether or not there has been significant insulation deterioration due to operational or environmental conditions.

The maintenance schedule for power cables only pertains to cables associated with critical equipment as defined in Section 1.3.2 of this document.

High potential tests (hipot) effectively reduce in service failures from faults of the cable or its accessories. When done properly, maintenance tests can detect problems in cables that are approaching failure without accelerating the deterioration process.

Except for infrared scanning, de-energize the cable circuit before maintenance. For assistance in determining appropriate test methods and voltage levels for a specific cable installation, contact the Hydropower Diagnostic and SCADA Group (86-68450) at 303-445-2300.

7.2 Maintenance Schedule for High Voltage Cables

Maintenance Task	Frequency	Reference
IR Scan, Cables.	Annually	FIST 4-13 Section 6.3.1
[DC, high-potential test]. DO NOT test XLPE with DC in "wet" Location.	**[5 years]**	FIST 3-1 Section 46

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8.0 Carbon Dioxide Systems

8.1 General

Carbon dioxide (CO_2) systems provide fire suppression for generator and large motor windings. These systems consist of CO_2 storage bottles or tanks, piping and valves, and electrical control systems.

8.2 Maintenance Schedule for CO_2 Systems

Maintenance Task	Frequency	Reference
[Inspect the CO_2 system. These checks are to give reasonable assurance that the extinguishing system is fully charged and operable. 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.]	**[Monthly]**	FIST 5-12 Section 15
[Check liquid level gauge. 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.]	**[Monthly]**	FIST 5-12 Section 15
[Check carbon dioxide storage is connected to discharge piping and actuators.]	**[Monthly]**	FIST 5-12 Section 15
[Check all manual actuators are in place and tamper seals are intact.]	**[Monthly]**	FIST 5-12 Section 15
[Check Nozzles are connected, properly aligned, and free from obstructions and foreign matter.]	**[Monthly]**	FIST 5-12 Section 15

Maintenance Task	Frequency	Reference
[Check detectors are in place and free from foreign matter and obstructions.]	**[Monthly]**	FIST 5-12 Section 15
[Check the system control panel is connected and showing the "normal-ready" condition.]	**[Monthly]**	FIST 5-12 Section 15
[Check the electrical control features by means of the test devices; this checks the continuity of the electrical control circuits where these are provided.]	**[Monthly]**	FIST 5-12 Section 15
[Check all gauge readings are normal]	**[Monthly]**	FIST 5-12 Section 15
[Weigh all CO_2 and replace 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.]	**[Semi-Annually]**	FIST 5-2 Section 6.4.3 (1) FIST 5-12 Section 7.2 FIST 5-12 Section 12.2
[Perform a functional test of the control/protection circuits. 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 5-12 Section 9.2 FIST 5-12 Section 15 Table 2 FIST 5-2 Section 6.4.3 (4)
[Calibrate the low-pressure system liquid level gauges.]	**[Annually]**	FIST 5-12 Section 15 Table 2
[Check low-pressure system liquid level gauges for losses.]	**[Weekly]**	FIST 5-12 Section 15 Table 2

Maintenance Task	Frequency	Reference
[Manually operate routing valves.]	**[Annually]**	FIST 5-2 Section 6.4.3 (4) FIST 5-12 Section 15 Table 2
[Perform simulated CO_2 emergency evacuation drill.]	**[Annually]**	FIST 5-12 Section 15 Table 2 FIST 1-2 Section 3.5
[Perform a CO_2 system functional test simulating an actual fire using smoke bombs, local heaters, or other methods to test operation of the detectors and sensors.]	**[5 years]**	FIST 5-12 Section 9.2 FIST 5-12 Section 15 Table 2
[Pressure test system hoses including flexible connectors.]	**[5 years]**	FIST 5-12 Section 15 Table 2
[Hydrostatically test CO_2 cylinders.]	**[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

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9.0 Circuit Breakers

9.1 General

Circuit breakers interrupt electrical current to stop power flow both for switching operations and during fault conditions.

Maintenance on critical molded case circuit breakers (MCCBs) must be performed on a periodic basis. If the MCCB is not critical, maintenance is recommended, but not required. Critical MCCBs are AC or DC breakers which feed circuits that control or operate critical equipment.

1. Molded case circuit breakers (480-Vac power type) can be located in motor starter cabinets, motor control centers, station service switchgear, or similar power distribution enclosures and auxiliary power panels. Breakers in this category or class usually have some type of adjustable trip capabilities. Adjustable settings for this class of breaker may have single trip adjustments, multiple trip adjustments, or solid-state tripping devices and modules. Final time delays and trip settings need to be coordinated closely with the specific equipment it is trying to protect. Settings should be verified by the Electrical Design Group of the Denver Technical Service Center.
2. Medium voltage circuit breakers generally are located in station-service metal clad switchgear or in separate enclosures as unit breakers. Examples are 4,160-Vac station service and 11.95- and 13.8-kV unit breakers. These breakers may be air, air blast, vacuum, or SF_6.
3. High voltage circuit breakers are located in separate breaker enclosures, either indoors or outdoors. These are oil, air-blast, or SF_6 breakers. Examples are 115- and 230-kV breakers located in the switchyard.
4. Extra high voltage (EHV) circuit breakers are not addressed in this FIST volume. Reference the manufacturers' instruction books.

Most breaker maintenance (except infrared scanning) must be performed with equipment de-energized.

9.2 Maintenance Schedule for Molded Case Circuit Breakers (MCCB)

Maintenance Task	Frequency	Reference
[Review equipment ratings and coordination study]	**[5 years]**	FIST 3-16, Section 3.3.1
[Visual inspection of Critical MCCBs]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 3.2.1
[Manual operation of Critical MCCBs]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 3.2.2
[Inverse-time over current and/or instantaneous trip test of critical MCCBs]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 3.2.3
Infrared scan and thermal analysis	Annually	FIST 3-16, Section 3.3.2
Visual inspection of non-critical MCCBs	Indoors: 6 years Outdoors: 3 years	FIST 3-16, Section 3.2.1
Manual operation of non-critical MCCBs	Indoors: 6 years Outdoors: 3 years	FIST 3-16, Section 3.2.2
Inverse-time over current and/or instantaneous trip test of non-critical MCCBs	Indoors: 6 years Outdoors: 3 years	FIST 3-16, Section 3.2.3
Insulation resistance test	Indoors: 6 years Outdoors: 3 years	FIST 3-16, Section 3.3.3
Contact resistance test	Indoors: 6 years Outdoors: 3 years	FIST 3-16, Section 3.3.3

9.3 Maintenance Schedule for Low-Voltage (600 V and Less) Draw-Out Air Circuit Breakers

Maintenance Task	Frequency	Reference
[Review equipment ratings and coordination study]	**[5 years]**	FIST 3-16, Section 4.2.7
[Visual inspection]	**[Annually]**	FIST 3-16, Section 4.2.1
[Preventive maintenance]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 4.2.2
[Manual operation]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 4.2.3
[Timing tests]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 4.2.4
[Insulation resistance test]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 4.2.5
[Contact resistance test]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 4.2.6
Infrared scan and thermal Analysis	Annually	FIST 3-16, Section 4.2.8 FIST 4-13

9.4 Maintenance Schedule for Medium Voltage (601 V – 15kV) Air and Air Blast Circuit Breakers

Maintenance Task	Frequency	Reference
[Review equipment ratings and coordination study]	**[5 years]**	FIST 3-16, Section 5.2.9
[Visual inspection]	**[Annually]**	FIST 3-16, Section 5.2.1
[Preventive maintenance]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 5.2.2
[Manual operation]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 5.2.3
[Insulation resistance test]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 5.2.4
[Contact resistance test]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 5.2.5
[Timing tests]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 5.2.6
[Motion analysis]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 5.2.7
[Breaker control functional testing]	**[Indoors: 6 years] [Outdoors: 3 years]**	FIST 3-16, Section 2.7
Infrared scan and thermal analysis	Annually	FIST 3-16, Section 5.2.10

9.5 Maintenance Schedule for Medium Voltage (601 V-15kV) Vacuum Circuit Breakers

Maintenance Task	Frequency	Reference
[Review equipment ratings and coordination study]	**[5 years]**	FIST 3-16, Section 6.2.9
[Visual inspection]	**[Annually]**	FIST 3-16, Section 6.2.1
[Preventive maintenance]	**[Indoors: 6 years]** **[Outdoors: 3 years]**	FIST 3-16, Section 6.2.2
[Manual operation]	**[Indoors: 6 years]** **[Outdoors: 3 years]**	FIST 3-16, Section 6.2.3
[Insulation and vacuum-integrity test]	**[Indoors: 6 years]** **[Outdoors: 3 years]**	FIST 3-16, Section 6.2.4 FIST 3-16, Section 6.3.1
[Contact resistance test]	**[Indoors: 6 years]** **[Outdoors: 3 years]**	FIST 3-16, Section 6.2.5
[Timing tests]	**[Indoors: 6 years]** **[Outdoors: 3 years]**	FIST 3-16, Section 6.2.6
Motion analysis	Indoors: 6 years Outdoors: 3 years	FIST 3-16, Section 6.2.7
[Breaker control functional testing]	**[Indoors: 6 years]** **[Outdoors: 3 years]**	FIST 3-16, Section 2.7
Infrared scan and thermal analysis	Annually	FIST 3-16, Section 6.2.10
Contact-erosion indicator check	Per Manufacturer O&M manual	FIST 3-16, Section 6.3.1

9.6 Maintenance Schedule for Medium and High Voltage Oil Circuit Breakers

Maintenance Task	Frequency	Reference
[Review equipment ratings and coordination study]	**[5 years]**	FIST 3-16, Section 7.2.10
[Inspect and test insulation oil]	**[Annually]**	FIST 3-16, Section 7.2.1
[Visual inspection]	**[Annually]**	FIST 3-16, Section 7.2.2
Infrared Scan and thermal analysis	Annually	FIST 3-16, Section 7.2.10
[Preventive maintenance]	**[6 years]**	FIST 3-16, Section 7.2.3
[Manual operation]	**[6 years]**	FIST 3-16, Section 7.2.4
[Insulation test]	**[6 years]**	FIST 3-16, Section 7.2.5
[Contact resistance test]	**[6 years]**	FIST 3-16, Section 7.2.6
[Breaker timing test]	**[6 years]**	FIST 3-16, Section 7.2.7
[Breaker motion analysis test]	**[6 years]**	FIST 3-16, Section 7.2.8
[Breaker control functional testing]	**[6 years]**	FIST 3-16, Section 2.7

9.7 Maintenance Schedule for Medium and High Voltage SF_6 Circuit Breakers

Maintenance Task	Frequency	Reference
[Review equipment ratings and coordination study]	**[5 years]**	FIST 3-16, Section 8.2.11
[Visual inspection]	**[Annually]**	FIST 3-16, Section 8.2.1
[Preventive maintenance]	**[6 years]**	FIST 3-16, Section 8.2.3
[SF6 gas analysis]	**[Annually]**	FIST 3-16, Section 8.2.4
[Manual operation]	**[6 years]**	FIST 3-16, Section 8.2.5
[Contact resistance test]	**[6 years]**	FIST 3-16, Section 8.2.7
[Timing tests]	**[6 years]**	FIST 3-16, Section 8.2.8
[Motion analysis]	**[6 years]**	FIST 3-16, Section 8.2.9
[Breaker control functional testing]	**[6 years]**	FIST 3-16, Section 2.7
[Internal circuit breaker inspection or overhaul]	**[12 years, 5,000 operations, or 3 high current interruptions]**	FIST 3-16, Section 8.2.12 Manufacturer's O&M manuals
Dynamic resistance measurement	6 years	FIST 3-16, Section 8.2.13 FIST 3-16, Section 8.3.2
Radiography Inspection	12 years or if problems are identified by other tests	FIST 3-16, Section 8.2.14 FIST 3-16, Section 8.3.3

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10.0 Control Circuits

10.1 General

The testing of control circuits used within this FIST only pertain to critical equipment as defined in Section 1.3.2 of this FIST.

Major equipment control circuitry is usually tested upon commissioning and functionality is confirmed during normal operation; however, some parts of a control circuit may not be exercised or there may be long intervals between uses.

Control circuits (usually 125 Vdc, 250 Vdc, or 120 Vac) provide the path for all control functions for major equipment in the powerplant. Reliability of these circuits is paramount. Although tested during commissioning, these circuits can become compromised over time through various means:

1. Modifications and construction work that unintentionally break circuit integrity or could introduce wiring errors
2. Age, misuse, and inadvertent damage or deterioration of wiring and connections rendering the system nonfunctional

Verifying the integrity of the control devices and interconnecting wiring requires a "functional test" of these circuits. Functional testing of control circuits may be considered completed in the course of normal plant operation. However, control circuits that rarely are used should be functionally tested on a periodic basis.

10.2 Maintenance Schedule for Control Circuits

Maintenance Task	Frequency	Reference
[Perform functional testing of critical control circuits.]	**[Upon installation, every 6 years thereafter, and upon any circuit changes.]**	PEB 43

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11.0 Coupling Capacitors

11.1 General

Coupling capacitor/voltage transformers (CCVTs) are instrument transformers that provide a path for communications, metering, control, and relaying equipment without allowing power system frequency energy to pass. These are static devices requiring relatively little maintenance. Maintenance must be conducted with equipment de-energized. This equipment normally is oil-filled and must be checked for oil leaks.

11.2 Maintenance Schedule for CCVT

Maintenance Task	Frequency	Reference
[De-energize and visually inspect for bulged case, chipped or cracked bushings, loose connections, and for oil leaks. **Check oil level of the base box by means of the oil gauge.** **Clean bushings.]**	**[5 years]**	PEB 55 Appendix 10
[Perform Powerfactor Test on CCVT]	**[5 years]**	FIST 3-25
{Verify that acceptable output signals (magnitude and phasing) are received at the protective relay if the CCVT is being used for protection relays.}	**[Upon commissioning,** **Every 6 years]** **{N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.2 PEB 51 Table 1 PSMP

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12.0 Overhead Cranes and Hoists

12.1 General

Cranes and hoists are important to the O&M of the facility. Proper maintenance of cranes and hoists will ensure they are ready for service, which will reduce time and cost of maintaining other equipment. Mechanical maintenance of cranes and hoists is covered in FIST 4-1A, Maintenance Scheduling of Mechanical Equipment. Only the electrical components are covered here.

The definitions and table below are excerpted from the electrical portions of FIST 4-1A. For complete requirements and references, see FIST 4-1A, Sections 6.2, 6.10.7.7, and 6.10.7.8.

12.2 Maintenance Schedule for Cranes and Hoists

Maintenance Task	Frequency	Reference
[Test all controls. Any controls that do not operate properly should be adjusted or repaired prior to the start of any operation.]	**[On each shift before operating the crane.]**	FIST 4-1A Section 6.5 FIST 4-1A Section 6.10.7
[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).]	**[On each shift before operating the crane.]**	FIST 4-1A Section 6.5 FIST 4-1A Section 6.10.7
[Check for excessive wear and contamination by lubricants or other foreign matter. Controls shall be kept clean, and function labels shall be kept legible.]	**[On each shift before operating the crane.]**	FIST 4-1A Section 6.5 FIST 4-1A Section 6.10.7
[Check 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	**[Annually]**	FIST 4-1A Section 6.5 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
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.]	**[Annually]**	FIST 4-1A Section 6.5 PEB 55 Appendix 11
[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 PEB 55 Appendix 11
[Inspect bridge conductors, trolley conductors, and collectors.]	**[Annually]**	FIST 4-1A Section 6.5 Table 2
[Inspect trolley and bridge motors, gear boxes, and shafts. **Grease bearings if not of the sealed type. Test motor insulation.]**	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[Check motor brushes for wear and slip rings for pitting. **Examine brushes for length and fit.** **Replace one at a time if badly worn.]**	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[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.**	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
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.]	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[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 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.]**	**[Annually]**	FIST 4-1A Section 6.10.7 PEB 55 Appendix 11
[Warning devices. **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

Maintenance Task	Frequency	Reference
[Bridge and trolley conductors and collectors. **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

13.0 Overhead Distribution Lines

13.1 General

Distribution lines carry medium voltage electrical power. The maintenance and inspection of distribution lines and their components are required.

13.2 Maintenance Schedule for Overhead Distribution Lines

Maintenance Task	Frequency	Reference
[Ground line 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 it is safe to do so every 12 years for sound poles and every 6 years for minor decay in previous inspection.]	**[12 years for sound poles; 6 years for minor decay in previous inspection.]**	FIST 4-6 Section 4.3.2 PEB 55 Appendix 12

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14.0 Transducers/Meters/Switches

14.1 General

Transducers convert electrical and mechanical data into electrical signals that may be used as inputs into monitoring systems. The accuracy and reliability of transduced signals are of extreme importance when used for metering, alarm, control, and protective functions. Examples of transduced data include:

- Bearing oil level or temperature read by a meter or scanning equipment
- Megawatt or megavars as input to the SCADA system

Meters indicate, and sometimes record, electrical and mechanical quantities. Some meters also transmit stored data to SCADA or other systems. The accuracy and reliability of meter indication are important to ensure correct power and water systems operation.

Switches can be actuated by a number of different devices including, but not limited to, pressure, flow, temperature, position, etc. These switches can be used in protection, control, or alarm circuits. The accuracy and reliability of these switches are important to ensure correct power and water systems operation.

14.2 Maintenance Schedule for Transducers/Meters/Switches

Maintenance Task	Frequency	Reference
[Test and calibrate transducers, meters, and switches]	**[3 years]**	Reclamation Standard Practice

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15.0 Emergency Lighting

15.1 General

Reliable plant emergency lighting is essential for personnel safety.

15.2 Maintenance Schedule for Emergency Lighting

Maintenance Task	Frequency	Reference
Observe all emergency lighting panels and alarms.	**Plant rounds**	PEB 55 Appendix 13
[A 30-second functional test shall be conducted on every required battery-powered emergency lighting system.]	**[Monthly]**	PEB 34 PEB 55 Appendix 13 NFPA 31
[A 1.5-hour functional test shall be conducted on every required battery-powered emergency lighting system.]	**[Annually]**	PEB 34 PEB 55 Appendix 13 NFPA 31

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16.0 Exciters and Voltage Regulators

16.1 General

Exciters and voltage regulators comprise excitation systems that provide appropriate direct current excitation for the field of generators and synchronous motors. Excitation systems may be rotating, static, or brushless and can be further categorized by the type of controller – electromechanical, magnetic amplifier, analog electronic, or digital electronic.

Components of excitation systems (e.g., transformers, circuit breakers, protective relays, annunciators, and buswork) require maintenance similar to that described in like sections of this document. Exciter and voltage regulator manufacturer's instructions may recommend supplemental maintenance tasks.

Automatic voltage regulator (AVR) performance testing ("alignment") is a specialty, requiring specialized training and unique equipment as well as knowledge of current power system stability requirements. It is recommended that performance testing be performed by qualified personnel. The Power System Analysis and Controls Group (86-68440) at 303-445-2300 has qualified staff to perform these tests.

16.2 Maintenance Schedule for Exciters and Voltage Regulators

Maintenance Task	Frequency	Reference
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.	Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.	PEB 55 Appendix 14
IR Scan	Annually	FIST 4-13 Section 6.3.1
[Automatic voltage regulator (AVR) and power system stabilizer (PSS) equipment shall be tested and calibrated as often as necessary to maintain calibration/performance]	**[Upon commissioning and every 5 years thereafter]**	PEB 55 Appendix 14 PEB 55 Appendix 17
[Perform power supply voltage check]	**[Plant rounds]**	Manufacturer's Guide
[Check to ensure that the power system stabilizer is in proper operation mode]	**[Plant rounds]**	Manufacturer's Guide

Maintenance Task	Frequency	Reference
[Check to ensure that the cabinet heaters are working properly]	**[Weekly]**	Manufacturer's Guide
[Verify that the fan failure annunciation is functional]	**[Monthly]**	Manufacturer's Guide
[Inspect the blower motor for excessive vibration and noise. If excessive check for damaged or worn bearings.]	**[Monthly]**	Manufacturer's Guide
[Inspect cabinet air filters and replace as necessary]	**[Monthly]**	Manufacturer's Guide
[Inspect the indicating lights, dampening elements, transfer switches and adjusting rheostats are in good working condition to ensure proper operation]	[Annually]	Manufacturer's Guide
Infrared scan and thermal analysis	Annually	Manufacturer's Guide
[Verify seamless transfer by swapping from auto to manual operation]	**[Annually]**	Manufacturer's Guide
[Drive VARs to over and under excitation limits to verify the operation of limiter]	**[Annually]**	Manufacturer's Guide
[Check and calibrate exciter panel meters]	**[3 years]**	Manufacturer's Guide
[Perform the exciter protective relays functional testing.] Skip if covered from section 26.	**[6 years]**	Manufacturer's Guide
[Verify alarm and trip circuits]	**[2 years]**	Manufacturer's Guide
[Inspect and clean exciter cabinets]	**[Annually]**	Manufacturer's Guide
[Check power leads for abrasions/cuts/general condition]	**[Annually]**	Manufacturer's Guide
[Check failover of redundant components]	**[Annually]**	Manufacturer's Guide

Maintenance Task	Frequency	Reference
[Check the integrity of frame grounding.]	**[Annually]**	Manufacturer's Guide
[Check wear, note color, polish or recondition to assure proper operation of commutator.]	**[Annually]**	Manufacturer's Guide
[Inspect brush rigging for loose bolts, connections and defective springs]	**[Annually]**	Manufacturer's Guide
[Test brush guide spring tension. Record tension pressure.]	**[Annually]**	Manufacturer's Guide
[Brush rigging: On generators of 500 kilowatts or synchronous motors of 500 hp and above, reverse field polarity]	**[5 years]**	Manufacturer's Guide
[Visually inspect brushes for correct length and proper contact. Adjust as necessary]	**[Annually]**	Manufacturer's Guide
[Examine contact points and burnish as needed. Inspect pivot points for free movement]	**[Annually]**	Manufacturer's Guide
[Clean out dust and dirt in the exciter housing]	**[Annually]**	Manufacturer's Guide
[Inspect condition of exposed parts of winding, insulation, connections, clamps, end turn lashing and related items]	**[Annually]**	Manufacturer's Guide
[Examine for loose taping, mechanical damage, and presence of oil or dirt in the coil and winding. Clean, repair and recoat with suitable insulating compound where necessary.]	**[Annually]**	Manufacturer's Guide
[Measure coil winding air gap clearances and record]	**[Annually]**	Manufacturer's Guide
[Check the rotor bus connection and power cable terminations for heating and loose connections]	**[During the unit outage]**	Manufacturer's Guide

Maintenance Task	Frequency	Reference
[Inspect rotor insulators and supports for breaks, cracks, or burns]	**[During the unit outage]**	Manufacturer's Guide
[Perform visual inspection of excitation breaker.] Skip if covered from breaker maintenance.	Applicable breaker Frequency	Manufacturer's Guide
[Check contact resistance of the breaker.] Skip if covered from breaker maintenance.	Applicable breaker Frequency	Manufacturer's Guide
[Perform breaker timing test.] Skip if covered from breaker maintenance.	Applicable breaker Frequency	Manufacturer's Guide
[Inspect fuses and fuse holders for connection tightness]	**[Annually]**	Manufacturer's Guide
[Perform testing of excitation transformer]	Applicable Transformer Frequency	Manufacturer's Guide
[Inspect thyristors]	**[Annually]**	Manufacturer's Guide
[Check the blower motor controller, and control wiring for signs of heating, loose terminations and contactor wear]	**[Annually]**	Manufacturer's Guide
[Check for loose blower mounting]	**[Annually]**	Manufacturer's Guide
[Inspect shaft suppression ground brush and associated circuitry]	**[Annually]**	Manufacturer's Guide
[Check the condition of the DC field flashing contactor and arc chute]	**[Annually]**	Manufacturer's Guide
[Perform the model verification/performance testing]	**[5 years]**	Manufacturer's Guide

17.0 Facility Equipment Ratings, ARC Flash, And Relay Reviews

17.1 General

Facility equipment conditions, operating configurations, replacement of equipment, available fault current, protective device settings, regulatory requirements, and other factors affecting electrical equipment can change over time. Periodic reviews that account for these changes are necessary to evaluate the impact to existing equipment ratings and capabilities, arc flash hazards, and protective relay settings. For assistance in performing a Power System Study and Facility Design Rating Review, Arc Flash Hazard Analysis, or Review of Protective Relaying, contact the Power System Analysis and Controls Group (86-68440) at 303-445-2300.

A Power System Study and Facility Design Rating review is an evaluation of the nameplate ratings of electrical equipment to determine its capability and suitability for the existing system design and operating configuration. This review shall include the tasks identified in the table below, as well as the following items:

1. Verification of equipment ratings and load requirements to identify the greatest load limiting component. This should include the complete powertrain and any equipment limitations, such as a turbine limitation.
2. Fault current analysis and verification of interrupting and short circuit withstand capabilities of electrical equipment on the main powertrain.
3. Review the nameplate ratings of the generator neutral grounding equipment to ensure it is appropriately sized.

17.2 Maintenance Schedule for Facility Equipment Ratings Review

Maintenance Task	Frequency	Reference
[Review the nameplate ratings of the arrestors to ensure this device is rated appropriately.]	**[5 years]**	PEB 44
[Review the nameplate ratings of the disconnect switch to ensure this device is rated appropriately.]	**[5 years]**	PEB 46
[Review ratings for switchyard conductors and bus in coordination with	**[5 years]**	PEB 55 Appendix 15

Maintenance Task	Frequency	Reference
power marketing agencies or local utilities.]		
[Review the ratings of medium-voltage bus including fuses and power cables 5 kV and above.]	**[5 years]**	PEB 55 Appendix 15
[Review ratings of generator circuit breakers, low-voltage (600V and below) draw out air breakers, medium-voltage (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.]	**[5 years]**	PEB 55 Appendix 15
[Review the ratings of instrument transformers including coupling capacitors.]	**[5 years]**	PEB 55 Appendix 15
[Review the ratings of transmission line and distribution line.]	**[5 years]**	PEB 55 Appendix 15
[Review the ratings of generator step-up transformers including all station and distribution (less than 500 kVA) type transformers, dry type power (500 kVA and larger) transformers, and any oil-filled power transformers.]	**[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 protective grounds.]	**[5 years]**	FIST 5-1A PEB 55 Appendix 15

17.3 Maintenance Schedule for Protective Relay Settings Review

Maintenance Task	Frequency	Reference
[Evaluate fault studies and load studies.]	**[5 years]**	FIST 3-8 Section 4.1 FIST 6-4 Section 4.1
{Verify Relay Settings are as specified}	**[5 years] {N}***	FIST 6-4 Appendix A.3 (#3)

17.4 Maintenance Schedule for Arc Flash Hazard Analysis

Maintenance Task	Frequency	Reference
[Update arc-flash hazard analysis.]	**[5 years]**	FIST 5-14 Section 10.1
[Review the short circuit interrupting capability of MCCBs, perform an equipment duty analysis to ensure this device is adequately rated to interrupt the available fault current]	**[5 years]**	PEB 45

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18.0 Fire Detection and Alarm Systems

18.1 General

Fire detection and alarm systems provide indication and warning of fire in the facility. They are crucial to safety of personnel and the public. Correct operation also may minimize damage to equipment by an early response. Regular maintenance of systems in unstaffed facilities is particularly important because O&M staff usually is not present to detect problems.

18.2 Maintenance Schedule for Fire Detection and Alarm Systems

Maintenance Task	**Frequency**	Reference
[Inspect portable fire extinguishers.] 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
Open blow-off lines for automatic sprinkler systems.	Monthly	FIST 5-2 Section 6.4.1

Maintenance Task	**Frequency**	Reference
[Perform a 30-second monthly backup battery power function test.] This can be accomplished by 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.	**[Monthly]**	PEB 55 Appendix 16
[Perform functional test of the control/protection circuits. **Verify 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
[Perform visual inspection 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
[Perform 90-minute battery discharge test.] 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
[Perform 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. **Or replace extinguisher.]**	**[5 years]**	FIST 5-12 Section 12.3
[Perform hydrostatic test stored pressure-dry chemical extinguishers.]	**[6 years]**	FIST 5-2 Section 3.3.4
[Perform 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. **Or replace extinguisher.]**	**[12 years]**	FIST 5-2 Section 3.3.4

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19.0 RESERVED

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20.0 Engine Generators

20.1 General

The general information that was provided in this section has been transferred to FIST 2-6. Please refer to FIST 2-6 for guidance on any Engine Generator related maintenance activities.

20.2 Maintenance Schedule for Engine Generators

The maintenance schedule for engine generator has been moved to FIST 4-1 A. Please refer to FIST 4-1A for the maintenance task description and the required frequency to perform the tasks.

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21.0 Generators and Large Motors (>500HP)

21.1 General

Generators produce electrical energy from mechanical power transmitted from the turbine. Large motors drive pumps to move water. Generators and large motors included in this section are synchronous machines performing the primary function of the power or pumping plant. Small motors are covered in Section 23, Motors (less than [<] 500 horsepower [hp]).

21.2 Maintenance Schedule for Generators and Large Motors

Maintenance Task	Frequency	Reference
[Check commutation or collector ring and brush operation.]	**[Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	PEB 55 Appendix 19
[Check bearing temperatures, lubrication, and oil level. **Check water leaks in bearing and cooling coils and surface air coolers.** **Check cooling water flow.]**	**[Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	PEB 55 Appendix 19
[Perform generator thrust-bearing insulation and oil film resistance test.]	**[Annually]**	FIST 3-11 FIST 4-1A Section 2.11.1-8 PEB 55 Appendix 19

Maintenance Task	Frequency	Reference
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 2.11.10
Perform Partial discharge test.	Annually	PEB 29
[Conduct insulation resistance and dielectric absorption test (PI) to identify factors in assessing serviceability of generator or large motor armature and/or field winding insulation.]	**[6 years]**	PEB 29 Page 24 PEB 55 Appendix 19 FIST 3-1 Sections 15 -19
[Perform an Armature Winding DC-Ramp Test.]	**[6 years]**	FIST 3-1 Section 39 PEB 29 PEB 55 Appendix 19
Perform Pole Drop Test.	Non-Routine. Perform during the rotor maintenance.	PEB 29

22.0 Reserved

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23.0 Motors (< 500 hp)

23.1 General

Motors of this type drive pumps, valves, gates, and fans. They are usually induction motors and are generally less than 500 hp but may be somewhat larger. Critical motors should be tested routinely. The maintenance schedule for motors (< 500 hp) only pertains to those associated with critical equipment as defined in Section 1.3.2 of this document.

23.2 Maintenance Schedule for Motors

Maintenance Task	Frequency	Reference
[Perform Insulation Resistance Test.]	**[Annually]**	FIST 3-4 Section 2.2 PEB 55 Appendix 21

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24.0 Personal Protective Equipment

24.1 General

Personal protective equipment (PPE) is used by maintenance workers to provide protection from hazardous electrical energy. Integrity of this equipment is paramount; therefore, maintenance should be scheduled and accomplished similar to equipment maintenance.

24.2 Maintenance Schedule for Personal Protective Equipment

Maintenance Task	Frequency	Reference
[Electrically test rubber insulating PPE including insulated gloves, and blankets and sleeves.]	**[Initially and Semi-annually thereafter]**	RSHS Section 8 PEB 55 Appendix 22
[Visually inspect ground cable assemblies, live-line tools including insulated gloves, and blankets and sleeves]	**[Before each use]**	FIST 5-1 Section 10.2 RSHS Section 8.5
[Perform personal protective ground cable millivolt drop test.]	**[Annually]**	PEB 29 Page 37 FIST 5-1 Section 10.3 FIST 5-1 Section 10.4 PEB 55 Appendix 22
[Functionally check electrical and electronic indicating type detectors.]	**[Before each use and Annually]**	FIST 5-1 Section 6.5 PEB 55 Appendix 22
[Hotsticks and live-line tools shall be electrically tested in a shop or laboratory.]	**[Annually]**	FIST 3-29 Appendix A FIST 5-1 Section 10.3 FIST 5-1 Section 10.4 PEB 55 Appendix 22
{AR clothing and arc flash suits must be inspected before each use. Those found to be damaged must not be used. Protective items that become contaminated with grease, oil, or flammable or combustible materials must not be used and must be cleaned immediately. AR clothing must be cleaned and maintained as specified by	**{Before each use}**	FIST 5-14 Section 9.3

Maintenance Task	Frequency	Reference
the clothing manufacturer. Cleaning of AR clothing, if performed according to manufacturer's requirements, has been shown to be very effective in removing contaminants and returning the garments to near original condition.}		

25.0 Potheads

25.1 General

Potheads provide mechanical support and electrical insulation for cables. Insulating capability of these devices is important to prevent a fault and resulting forced outage. Potheads, being an integral part of a cable, generally are tested when the cable is tested.

25.2 Maintenance Schedule for Potheads

Maintenance Task	Frequency	Reference
IR Scan	Annually	FIST 4-13 Section 6.3.1
[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
[Perform Hot Collar (Power factor) Test]	**[5 years]**	FIST 3-1 Section 50 – 56 PEB 55 Appendix 23
[Perform DC High Pot Test]	**[5 years]**	FIST 3-1 Section 46 PEB 55 Appendix 23

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26.0 Relays and Protection Circuits

26.1 General

Protective relays provide critical protection functions for all types of plant equipment associated with power generation and power delivery. The protective devices must operate during abnormal plant operating conditions and, in most instances, are the last line of defense to protect equipment from a catastrophic failure. It is critical, then, that these protective devices function properly to adequately protect the associated piece of equipment and that adjustments and calibrations are routinely conducted to eliminate the possibility of the protective device misoperation. Therefore, it is imperative to conduct periodic maintenance testing to validate that the operational parameters of the functional protective device are properly set and coordinated.

Protective relays currently in use within Reclamation include electromechanical, solid-state, and microprocessor-based packages. The protection relays contained within this FIST section also shall include the lockout relay to ensure that the proper operational and functional testing of the device and associated control circuits is performed on a regular maintenance interval as prescribed in the associated table. Calibration and maintenance recommendations differ from type to type because of the different design and operating features of the protective device.

26.1.1 Calibration and Maintenance

This process usually includes removing the relay from service to a test environment. Injecting current and/or voltage into the relay and observing the response according to the manufacturer's test procedure verifies the recommended settings. Calibration of electromechanical relays is recommended frequently since operating mechanisms can wear and get out of adjustment. Calibration of solid-state and microprocessor-based relays is recommended less frequently since there are fewer ways for them to get out of calibration.

26.1.2 Relay Functional Test

This process verifies that the protective outputs of the relay (e.g., contact closures) actually operate as intended. This can be accomplished as part of the calibration procedure in most cases, but relay functional testing should be verified according to the prescribed maintenance schedule associated with the particular type of relay being tested.

26.1.3 Protection Circuit Functional Testing

Protective relays operate into protection circuits to accomplish the desired protective action. Similar to control circuits, protection circuit integrity may be compromised by construction, modifications, deterioration, or inadvertent damage. A compromised protection circuit may not provide the system and plant protection desired. Periodic functional testing is recommended to ensure the integrity of protection circuits.

This process verifies that the entire protective "trip path" from protective relay through circuit breakers (or other protective equipment) is intact and functional. This requires actually operating the entire circuit to verify correct operation of all components.

26.2 Maintenance Schedule for Electromechanical Relays

Maintenance Task	Frequency	Reference
{Perform electromechanical relay calibration and functional testing.}	**[Every year in harsh conditions and every 2 years in controlled environments.] {N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 12 PSMP
{Verify that acceptable instrument transformer output signals are received at the protective relay.}	**[6 years] {N}***	FIST 3-8 Section 3 Table 1 PEB 51 Table 1 PSMP

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

26.3 Maintenance Schedule for Solid-State Relays

Maintenance Task	Frequency	Reference
[Perform visual inspection to verify relay power indicating light is illuminated.]	**[Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	PEB 55 Appendix 24
{Perform solid-state relays calibration and functional testing.}	**[2 years] {N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 13.1
{Verify that acceptable instrument transformer output signals are received at the protective relay.}	**[6 years] {N}***	FIST 3-8 Section 3 Table 1 PEB 51 Table 1

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

26.4 Maintenance Schedule for Microprocessor Relays

Maintenance Task	Frequency	Reference
[Perform visual inspection on unmonitored microprocessor based relays to check for relay trouble indication.]	**[Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	PEB 55 Appendix 25
{Perform microprocessor (digital) relay input and output verification.}	**[2 years] {N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 14.2 PEB 51 Table 1
{Perform microprocessor (digital) relay functional testing – Unmonitored.}	**[4 years] {N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 14 PSMP
[Perform microprocessor (digital) relay setting verification and documentation.]	**[4 years or, immediately following relay changes (firmware, software, relay settings) or following a relay operation]**	FIST 3-8 Section 3 Table 1 PEB 51 Table 1
{Perform microprocessor (digital) relay functional testing – Monitored.}	**[6 years] {N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 14 PSMP
{Verify only the unmonitored relay inputs and outputs of a monitored Protection System that are essential to proper functioning of the Protection System.}	**[6 years] {N}***	PSMP
{Verify that acceptable instrument transformer output signals are received at the protective relay.}	**[6 years] {N}***	FIST 3-8 Section 3 Table 1 PEB 51 Table 1 PSMP

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

26.5 Maintenance Schedule for 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.]	**[Once a week at an unmanned facility or on a per shift basis at a facility with operations staff.]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Sections 8, 9.4 PEB 51 Table 1

Maintenance Task	Frequency	Reference
{Perform functional testing of lockout relays} **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. Auxiliary relays may be a critical component of protection circuits, and it is important to include these relays when performing functional testing.**	**[Upon installation,** **Every 2 years,** **After any wiring changes** **After any misoperation]** **{N}***	FIST 3-8 Section 8 FIST 3-8 Section 9.2 PSMP

Maintenance Task	Frequency	Reference
[Perform sealed lockout relay timing test.] **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.**	**[2 years]**	FIST 3-8 Section 3 Table 1 PEB 51
[Perform non-sealed lockout relay timing tests, cleaning, and lubrication. **Note: Lockouts may not need to be oiled or cleaned; see manufacturer's instructions.]** **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.**	**[6 years]**	FIST 3-8 Section 3 Table 1

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

26.6 Maintenance Schedule for Protection Circuits

Maintenance Task	Frequency	Reference
{Perform protective circuit functional testing} 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. 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.	**[Upon installation,** **Every 2 years,** **After any wiring changes** **After any misoperation]** **{N}***	FIST 3-8 Section 8 FIST 3-8 Section 9.2 PSMP

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

26.7 Maintenance Schedule for Communication Systems for Protective Relaying

Maintenance Task	Frequency	Reference
{Perform functional tests on all unmonitored protection system communications equipment and channels required for correct operation of protection systems.}	[Upon commissioning, Quarterly, And after wiring modifications] {N}*	FIST 3-8 Section 14.9 PEB 51 Table 1 PSMP
{Performance test all unmonitored protection system communications equipment and channels required for correct operation of protection systems.}	[Upon commissioning, Every 4 years, And after wiring modifications] {N}*	FIST 3-8 Section 14.9 PEB 51 Table 1 PSMP
[Perform functional testing on all monitored protection system communications equipment and channels required for correct operation of protection systems.]	[Upon commissioning, Every 6 years, And after wiring modifications]	FIST 3-8 Section 14.9 PEB 51 Table 1
{Verify only the unmonitored communications system inputs and outputs of a monitored communication system that are essential to proper functioning of the Protection System.}	[Upon commissioning, Every 6 years, And after wiring modifications] {N}*	PSMP
{Performance test all monitored protection system communications equipment and channels required for correct operation of protection systems.}	[Upon commissioning, Every 6 years, And after wiring modifications] {N}*	FIST 3-8 Section 14.9 PEB 51 Table 1 PSMP

Maintenance Task	Frequency	Reference

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

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27.0 SCADA Systems, ICS and Voice Communication

27.1 General

Supervisory Control and Data Acquisition (SCADA) systems and Industrial Control systems (ICS) are computer-based, real-time control systems. Theses SCADA systems are used to monitor and control water and power operations at a variety of Reclamation facilities. These systems operate continuously and, in many ways, are self-diagnosing; but some maintenance and testing of these devices are necessary to ensure system integrity and identify potential failures. As well, circuits that are infrequently used may require periodic functional testing to ensure they will be operational when the need arises.

Although FIST 3-33 covers requirements for management, operational, maintenance, and technical support training and documentation requirements, the section listed below will focus only on the requirements associated with maintenance and general operational inspections.

27.1.1 Input and Output Circuit Functional Testing

The functional testing process (also considered points checks) verifies the correct operation of all components within the circuit path. Therefore, functional testing requires activation of an initiating device (in the field), monitoring of the point into the SCADA system for correct operation, and activation of the correct SCADA output point as anticipated.

27.2 Maintenance Schedule for SCADA Systems

Maintenance Task	Frequency	Reference
[Test radio, telephone, satellite, and cellular systems used for voice communication by establishing a voice contact, verifying clear reception, and logging the result.]	**[Monthly]**	PEB 55 Appendix 26
[Test unmonitored analog SCADA communication equipment. **Test the overall performance of the communication schemes, including logic, signal quality, and overall performance to validate the SCADA performance.]**	**[Upon commissioning,** **Quarterly,** **and after wiring modifications]**	PEB 55 Appendix 26

Maintenance Task	Frequency	Reference
[Test monitored analog SCADA communication equipment. **Test the overall performance of the communication schemes, including logic, signal quality, and overall performance to validate the SCADA performance.]**	**[Upon commissioning,** **every 5 years,** **and after equipment modifications.]**	PEB 55 Appendix 26
[Check alarm inputs.]	**[2 years]**	FIST 3-33 Section 7.1.2.2
[Test UPS Loading. The input power should be switched off, and the load on the UPS and the duration that load can be supported should be measured.]	**[Annually]**	FIST 3-33 Section 7.1.2.3 PEB 55 Appendix 26
[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
[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.]	**[2 years]**	FIST 3-33 Section 7.1.2.2 PEB 55 Appendix 26

28.0 Security Systems

28.1 General

Reclamation facilities face a number of threats from various sources. As such, electronic, physical, and procedural safeguards have been put in place to detect, deter, delay, and deny potential threats and intrusions. These safeguards provide access control, intrusion detection, and surveillance. Additionally, these systems provide auditing and accountability logs for review by designated security staff. Routine maintenance will ensure these safeguards continue to operate as designed.

28.2 Maintenance Schedule for Security Systems

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on alarm system enclosures.] Inspect the alarm panel for damage (electrical or physical), loose connections, or foreign debris such as dirt, dust, and metal shavings. Inspect the alarm panel to ensure the LED's are properly illuminated to show operational status (refer to system owner's manual for information on LED status). Inspect the on-board battery status. If it is greater than three years old, showing symptoms of failure, or is generating an alarm, replace it. See manufacturer's recommendation. Repair or replace as necessary. Clean with compressed air to remove dust, dirt, or debris.	**[Semi-Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform alarm panel functional test.] Ask alarm monitor to verify panel is on-line using the ESS software at the alarm monitor client workstation. The alarm panel will be either off-line or on-line.	**[Annually]**	PEB 59 Table 1
[Perform card reader preventative maintenance.] Inspect card reader. Inspect the card reader for damage (electrical or physical) and loose connections. Inspect LED lights and light bars to verify proper operation. Repair or replace as necessary. Clean exterior of card reader with dry or damp cloth as needed to remove oil, dust, and debris.	**[Annually]**	PEB 59 Table 1
[Perform card reader functional test.] For a card reader that is not routinely used, the documented functional test of the electronic strike or magnetic lock can also be used to satisfy the functional test of the card reader.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on balanced magnetic switches (BMS).] Inspect BMS. There should be no metal filings or other debris on the sensor. Wire insulation should be free of damage and in good condition (free of nicks, exposed copper, etc.). Armored cable should be free of nicks, gaps, and burrs which could damage the wiring, device, or personnel. Repair or replace as necessary. Clean with dry or damp cloth as needed to remove oil, dust, and debris.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on balanced magnetic switches (BMS).] Use a key to open the door. The alarm monitor should receive a door forced open alarm. Continue holding the door open. Depending on how the door is configured, a door held alarm should report to the system after 30-60 seconds. Close the door; the door held alarm should clear. Select and acknowledge the door forced open alarm. The alarm should clear. Using a valid card, gain access to the door by presenting it to the card reader. Alarm monitor should report a valid access, displaying cardholder information (if that feature is available). Some systems have an alternate wiring configuration which does not generate a door forced open or door held open alarm. If your system is configured in this manner, contact SSLE Security Office for alternate procedures.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on magnetic locks.] Inspect magnetic lock. Verify proper alignment of metal plate attached to door and electro-magnetic assembly on frame. See manufacturer's documentation for proper alignment procedure. There should be no metal filings or other debris on metal parts. Repair or replace as necessary. Clean with dry or damp cloth as needed to remove oil, dust, and debris.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on magnetic locks.] With door in the secure position (closed), try to open the door. (Most magnetic locks require a pressure greater than 500 pounds to defeat.) The door must remain closed and not activate the door contact. Using a valid card, gain access to the door by presenting it to the card reader. Alarm monitor should report a valid access, displaying cardholder information. The magnetic lock should release and the door should open normally. Continue holding the door open. Depending on how the door is configured, a door held alarm should report to the system after 30-60 seconds. Allow door to close. Do not interfere with the natural action of the door closing. When the door closes, the magnetic lock should activate and the door held alarm should clear. Select and acknowledge the door held alarm. The alarm should clear. Push on door again and verify it remains secure.	**[Annually]**	PEB 59 Table 1
[Perform preventative maintenance on electronic locks/strikes.] Inspect electronic lock/strike for missing hardware. Repair or replace as necessary. Clean with dry or damp cloth as needed to remove oil, dust, and debris.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[**Perform functional test on electronic locks/strikes]** With the door in the secure position (closed), try to open the door. The door must remain closed and not activate the door contact. Using a valid card, gain access to the door by presenting it to the card reader. Alarm monitor should report a valid access, displaying cardholder information. The electronic strike or latch should release and the door should open normally. Continue holding the door open. Depending on how the door is configured, a door held alarm should report to the system after 30-60 seconds. Allow the door to close, do not interfere with the natural action of the door closing. When the door closes, the electronic strike should activate. The door held alarm should clear. Select and acknowledge the door held alarm. The alarm should clear. Push on door again and verify it remains secure.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on motion detectors.] Inspect motion detector. Inspect for missing hardware. Inspect for damage (e.g. cracked housing, proper mounting, etc.). Repair or replace as necessary. If motion detector is damaged, order new motion detector and replace as soon as possible. Clean with dry or damp cloth as needed to remove oil, dust, and debris.	**[Semi-annually]**	PEB 59 Table 1
[Perform functional test on motion detectors.] Have personnel stand outside the detection area and walk slowly towards the motion detector. An alarm should be activated when motion is detected while walking through the motion detection area.	**[Annually]**	PEB 59 Table 1
[Perform preventative maintenance on tamper switches.] Inspect tamper switch. Inspect plunger for mechanical actuation (plunger moves freely in and out). Inspect for loose wiring and exposed cooper. Repair or replace as necessary. Clean with dry or damp cloth as needed to remove oil, dust, and debris.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on tamper switches.] Open the device, the alarm monitor should receive a tamper alarm. Close the device, the alarm should clear. The alarm monitor needs to select and acknowledge the alarm; then the alarm should clear.	**[Annually]**	PEB 59 Table 1
[Perform preventative maintenance on fixed, PTZ, and thermal camera enclosures.] Inspect enclosure. Inspect exterior of enclosure for damage. Minor scratches and dents are to be expected. Enclosures located in temperature controlled areas which have minor paint damage are acceptable. Major paint damage (larger than 1") or paint damage on devices in uncontrolled climate areas must be repaired. Inspect utilized knockout holes to ensure conduit/enclosure connecters are tight and cables are not being damaged during transition. Inspect knockout holes not being utilized to ensure they have original plugs or are plugged using appropriate equipment/ knock out blanks. Repair or replace as necessary. Clean the exterior and interior.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on dome cameras (fixed, PTZ, and thermal).] Inspect dome camera. Inspect cables, connectors, and cable shielding between enclosure, pole and camera for abrasions, cracks, or deterioration. Inspect for damage on the camera housing, including insect damage, lightning damage, and/or other mechanical failure. Repair or replace as necessary. Clean camera housing, dome bubble, and lenses.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on dome cameras (fixed, PTZ, and thermal).] **Fixed Camera Functional Test** Verify that user is able to zoom in/out. (Not applicable on all fixed cameras.) Close the iris to reduce the light (darkening the image) and open the iris to increase the light (lightening the image). Restore the iris to optimal view upon completion. Verify that the user is able to use the manual focus to change the focal point in the image. Auto-focus will re-enable once the camera is moved. (Not applicable on all fixed cameras.) **PTZ and Thermal Camera Functional Test** Verify that video image is clear and presentable. Verify that user is able to pan the camera left and right, tilt the camera up and down, and zoom in/out. Close the iris to reduce the light (darkening the image) and open the iris to increase the light (lightening the image). Restore the iris to optimal view upon completion. (This test is not applicable on thermal cameras.) Verify that the user is able to use the manual focus to change the focal point in the image. Auto-focus will re-enable once the camera is moved. (This test is not applicable on thermal cameras.)	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on box cameras (fixed, PTZ, and thermal).] Inspect box camera. Inspect cables, connectors, and cable shielding between enclosure, pole and camera for abrasions, cracks, or deterioration. Inspect for damage on the camera housing, including insect damage, lightning damage, and or other mechanical failure. Repair or replace as necessary. Clean camera housing, housing window, and lenses.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on box cameras (fixed, PTZ, and thermal).] **Fixed Camera Functional Test** Verify that user is able to zoom in/out. (Not applicable on all fixed cameras.) Close the iris to reduce the light (darkening the image) and open the iris to increase the light (lightening the image). Restore the iris to optimal view upon completion. Verify that the user is able to use the manual focus to change the focal point in the image. Auto-focus will re-enable once the camera is moved. (Not applicable on all fixed cameras.) **PTZ and Thermal Camera Functional Test** Verify that video image is clear and presentable. Verify that user is able to pan the camera left and right, tilt the camera up and down, and zoom in/out. Close the iris to reduce the light (darkening the image) and open the iris to increase the light (lightening the image). Restore the iris to optimal view upon completion. (This test is not applicable on thermal cameras.) Verify that the user is able to use the manual focus to change the focal point in the image. Auto-focus will re-enable once the camera is moved. (This test is not applicable on thermal cameras.)	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on sealed cameras (fixed, PTZ, and thermal).] Inspect sealed cameras. Inspect cables, connectors, and cable shielding between enclosure, pole and camera for abrasions, cracks, or deterioration. Inspect for damage on the camera housing, including insect damage, lightning damage, and or other mechanical failure. Repair or replace as necessary. Clean camera assembly (camera housing, PTZ housing, and power supply housing and mount) and lenses.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on sealed cameras (fixed, PTZ, and thermal).] **Fixed Camera Functional Test** Verify that user is able to zoom in/out. (Not applicable on all fixed cameras.) Close the iris to reduce the light (darkening the image) and open the iris to increase the light (lightening the image). Restore the iris to optimal view upon completion. Verify that the user is able to use the manual focus to change the focal point in the image. Auto-focus will re-enable once the camera is moved. (Not applicable on all fixed cameras.) **PTZ and Thermal Camera Functional Test** Verify that video image is clear and presentable. Verify that user is able to pan the camera left and right, tilt the camera up and down, and zoom in/out. Close the iris to reduce the light (darkening the image) and open the iris to increase the light (lightening the image). Restore the iris to optimal view upon completion. (This test is not applicable on thermal cameras.) Verify that the user is able to use the manual focus to change the focal point in the image. Auto-focus will re-enable once the camera is moved. (This test is not applicable on thermal cameras.)	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on camera poles.] Inspect pole. Wood pole: check for cracking, damage and rot. Metal pole: check for cracking, damage, metal fatigue, mechanical damage, and corrosion. Concrete pole: check for cracking, damage, and exposed rebar. Repair or replace as necessary.	**[Annually]**	PEB 59 Table 1
[Perform preventative maintenance on radars.] Inspect radar. Radars are sealed units and only the exterior should be inspected. The front of the radar is made of a thin material which is transparent to RF transmission. This material is easy to damage. Take care when working on the radar. Inspect casing for damage. Paint damage on casing must be repaired. Inspect front of radar for rips or holes. Inspect wiring and ensure connector is secure. Inspect mount and cable. Verify mounting hardware is tight and free of corrosion. Repair or replace as necessary. Do not repair damage to the front of the radar. If damage is found, other than the paint damage to the casing noted in a. above, the unit must be replaced.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on radars.] Have a subject walk/drive (if over land), or operate a watercraft (if over water) in a restricted area covered by the radar and verify an alarm is received. Once subject is clear of restricted/exclusion area, the alarm should clear. Select and acknowledge the alarm. The alarm should clear. Have a subject walk/drive (if over land), or operate a watercraft (if over water) in an unrestricted zone and verify no alarm is received.	**[Annually]**	PEB 59 Table 1
[Perform preventative maintenance on digital/network video recorders (DVR/NVR).] Inspect DVR/NVR. Inspect connectors for damage and exposed copper. Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring). Inspect wiring for damage. Verify optical disk drive tray opens/closes properly. Repair as or replace necessary. Clean enclosure using a dry cloth to remove dust, dirt, and debris. If the DVR/NVR has a fan, clean fan assembly using compressed air.	**[Semi-annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on digital/network video recorders (DVR/NVR).] Verify display of video using the DVR/NVR as the video source. Verify configuration settings (e.g. record on motion, schedule, record 24/7, etc.) are properly set according to local configuration requirements. Verify that time stamp is consistent between all cameras and the ESS system (if applicable) and that the time stamp is accurate. Verify that video is recording according to configuration settings referenced above. Select a 5 minute segment of recorded video from the DVR/NVR and export using the following removable media: CD or DVD, USB Replay the video and verify that the playback is free of static and interference and the image is clear.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on security system network components (switches, encoders, decoders, etc.).] Inspect network device (e.g. switches, encoder, decoder, etc.). Inspect connectors for damage and exposed copper. Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring). Inspect wiring for damage. Listen for any excessive vibrations or noise from the fan or power supply. Repair or replace as necessary. Clean enclosure using a dry cloth to remove dust, dirt, and debris. If the network component has a fan, clean fan assembly using compressed air.	**[Annually]**	PEB 59 Table 1
[Perform functional test on security system network components (switches, encoders, decoders, etc.).] Operational status verified through daily use.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on the exterior of security system computers.] Inspect computers (e.g. workstations and servers) and peripherals. Inspect connectors for damage and exposed copper. Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring). Inspect wiring for damage. Listen for any excessive vibrations or noise from the fan or power supply. Repair or replace as necessary. Clean enclosure using a dry cloth to remove dust, dirt, and debris. If the computer has a fan, clean fan assembly using compressed air.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on the interior of security system computers.] Inspect the interior of the computer. Inspect connectors for damage and exposed copper. Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring). Inspect wiring for damage. Listen for any excessive vibrations or noise from the power supply or system fans. Repair or replace as necessary. Verify, using manufacturers recommendations, whether or not the part is a reparable or replaceable part. Some failures may require replacement of the computer. Clean interior of computer and fans using compressed air to remove dust, dirt, and debris.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform preventative maintenance on battery/battery system.] Inspect battery. Check battery for warping, cracking, or bulging. Check battery terminals for corrosion. Repair or replace as necessary. If battery shows warping, cracking, or bulging, battery must be replaced. It is recommended that the batteries be replaced every three years even if annual testing verifies proper battery operation. Clean exterior using a dry cloth to remove dust, dirt or debris.	**[Annually]**	PEB 59 Table 1
[Perform functional test on battery/battery system.] Operational status verified through daily use.	**[Annually]**	PEB 59 Table 1
[Perform preventative maintenance on power supply/board.] Inspect power supply/board, such as Altronix PD8, Altronix power supplies, 24VAC camera power supplies, etc. Check for cracking of components and wiring. Check for scorch marks and loose wiring on components and at terminal connections. Repair or replace as necessary. Clean power supply/board using compressed air to remove dust, dirt or debris.	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
[Perform functional test on power supply/board.] Operational status verified through daily use.	**[Annually]**	PEB 59 Table 1

[Perform preventative maintenance on vehicle barriers.] Inspect automated vehicle barrier (AVB) equipment: Related safety devices (including induction safety loop detectors) and warning signs/signals/lights. Check and adjust barrier operating speeds (where appropriate). Covers and protective plates on equipment to prevent water or wildlife damage. Hoses for damage, cracking, leaking and wear. Safety signs, decals, and appropriate stickers and replace as necessary. Hinge pins; lubricate when needed. Relays, motor starters, and switches for signs of contact wear. Indicator lights and traffic lights for proper operation; replace bulbs as necessary. Areas that need touch-up paint or corrosion protection. All cabling and wiring for control and operating devices for wear, indications of pinch or drag during operation, etc. (Consider re-routing, additional protection (armoring), or replacement where wire or cable shows excessive wear or damage that could result in grounding-out or interrupting power or signals.) Repair or replace as necessary. Clean complete barrier system using appropriate methods, which may include	**[Annually]**	PEB 59 Table 1

Maintenance Task	Frequency	Reference
high pressure water/air, manually brushing, or other means (alone or in combination). Foundation, hinges, and tracks to prevent interference from dirt, stones, or trash; pick up remaining bits with small handheld broom and dustpan. Remove debris from all sump areas and system cabinets; clean and flush drains. For system specifics and hydraulic fluid capacities, refer to the manufacturers manual and recommendations.		
[Perform functional test on vehicle barriers.] Verify barrier cycle up and down times to be within manufacturer's specifications. (Refer to owner's manual)	**[Annually]**	PEB 59 Table 1
[Perform functional test on request to exit.] As personnel exiting through the door, the REX should detect movement before the door threshold and grant a request to exit prior to opening the door. The motion detector should detect motion within two steps of entry through the door threshold. If the motion detector does not activate, a door forced open alarm will appear at the alarm monitor's station when the door is opened.	**[Annually]**	PEB 59 Table 1

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29.0 Disconnect Switches

29.1 General

When open, disconnect switches permit isolation of other power system components, thus facilitating safety during maintenance procedures. Disconnect switches may be manually or motor operated and, in some cases, may integrate fuse protection. Preventive maintenance shall be considered synonymous with any type of general maintenance, major maintenance, or overhaul functions to be performed on the equipment.

29.2 Maintenance Schedule for Disconnect Switches

Maintenance Task	Frequency	Reference
[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; ensure linkages and operating rods have not bent or distorted. Mechanical linkages and operating rods – Ensure linkages and operating rods have not been bent or distorted; ensure all fastenings (bolts, nuts, etc.) are secure. 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.	**[Semi-annually** **Or after a short circuit event]**	PEB 46

Maintenance Task	Frequency	Reference
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 bolts and nuts are secure.		
[Verify proper operation of disconnect switch.] Ensure 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
IR Scan	Annually	PEB 46
[Perform Preventive Maintenance]	**[6 years Indoor, 3 years Outdoor]**	PEB 46

30.0 Switchyard/Substation Ground Connections

30.1 General

Grounding is an essential part of protecting staff and equipment from high potential caused by electrical faults. Grounding conductors of switchyard equipment and gate structures are subject to failure due to corrosion, loose connections, and mechanical damage. Grounding also may be compromised during equipment addition and removal or other construction type activities. Verifying grounding system integrity through periodic testing is an important maintenance activity. (The Hydropower Diagnostics and SCADA Group (86-68450) at 303-445-2300 has qualified staff to perform ground system testing.)

30.2 Maintenance Schedule for Switchyard/Substation Ground Connections

Maintenance Task	Frequency	Reference
[Visually inspect structures and apparatus] Verify ground leads (jumpers) are not loose, or broken. Check and tighten connectors and clamps in ground leads.	**[Annually]**	PEB 55 Appendix 27
[Test ground mats.]	**[6 years]**	PEB 55 Appendix 27

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31.0 Switchyards, Substations, and Transmission Lines

31.1 General

Switchyards, substations, and transmission lines are used to deliver high voltage electrical power.

31.2 Maintenance Schedule for Switchyards, Substations, and Transmission Lines

Maintenance Task	Frequency	Reference
[Check 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.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check 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.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check valves on active storage tanks, which can be operated without a wrench to verify they are plugged or locked closed.]	**[Semi-annually]**	PEB 55 Appendix 28
[Drain condensate from storage tank sump.]	**[Semi-annually]**	PEB 55 Appendix 28
[Repaint tanks and piping if necessary.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check operation of oil pumps.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check hoses and other accessories used in draining or refilling apparatus tanks.]	**[Semi-annually]**	PEB 55 Appendix 28

Maintenance Task	Frequency	Reference
[Verify power is available on all essential power, lighting, and control circuits.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check fuses or circuit breakers on power, lighting, and control circuits]	**[Semi-annually]**	PEB 55 Appendix 28
[Check and tighten wiring connections at terminal points.]	**[Semi-annually]**	PEB 55 Appendix 28
[Inspect wiring for open circuits, short circuits, and damaged insulation.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check insulation resistance of wiring with devices connected.]	**[Semi-annually]**	PEB 55 Appendix 28
[Perform ground pole inspection. **From the ground up, check transmission wood poles for signs of decay, misalignment, and damage from lightning or other causes.** **Check cross arms for splitting.]**	**[Semi-annually]**	PEB 55 Appendix 28

Maintenance Task	Frequency	Reference
[Perform steel structure from-the-ground check. **Check the structures 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.** **Check for 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.]**	**[Semi-annually]**	PEB 55 Appendix 28
[Perform from-the-ground inspection of main conductors and overhead 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.]**	**[Semi-annually]**	PEB 55 Appendix 28

Maintenance Task	Frequency	Reference
[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.]	**[Semi-annually]**	PEB 55 Appendix 28
[Check switchyards and substations fences 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.** **Remove rubbish.** **Check danger signs on fence and gates.]**	**[Annually]**	PEB 55 Appendix 28
[Perform transmission line maintenance. **Patrol transmission line rights-of-way.]**	**[Annually]**	PEB 55 Appendix 28

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33.0 Elevators

33.1 General

There are over 125 elevators at various Bureau of Reclamation pumping plants, powerplants, dams, office buildings, tunnels, and visitor facilities. The safety of these elevators is an ongoing concern of Reclamation. While elevators are generally considered to be an extremely reliable and safe means of vertical transportation, it is only by a thorough program of inspection and testing that they can be considered to be so. A malfunctioning elevator system potentially may cause loss of life or serious injury. Many of the elevator systems at Bureau facilities are aging and may not have had a reliable record of inspection and maintenance. Many of these elevators may lack some of the safety features that are required by code to build an elevator today.

A strong preventive maintenance program, combined with scheduled testing, will help to ensure future safety, performance, and economy of Reclamation elevators.

When determining the maintenance intervals, take into account the manufacturer's recommendations, how often the elevator is used, the severity of equipment loading, the age and wear of the equipment, the equipment's operating environment, and the inherent quality of the equipment.

33.2 Maintenance Schedule for Elevators

Maintenance Task	Frequency	Reference
[Electric traction elevator maintenance/testing] Ride in the car to observe operation of doors, leveling, smoothness, and door reopening devices at each landing. Listen for unusual noises in the car and in the hoistway. Check all car operating controls, lamps, and gongs. Replace burned-out lamps. Clean: Door reopening device photo eye components Lamps and sensors in the car top controller Brushes and commutator	**[Weekly]**	FIST 2-10 Appendix B FIST 2-10 Section 4.3.1 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
Controller Selector Relay connectors Contacts. Check operation of the brake and adjust or repair if necessary.		
Inspect and lubricate (as required) machinery, sheaves, worm, gear, motor, brake, selector, and controller.	Weekly	FIST 2-10 App B
Clean: Drip pans (check oil levels of associated equipment) Door reopening device photo eye components Door tracks and sills Lamps and sensors in the car top controller Car top Machine room Pit Brushes and commutator Controller Selector Relay connectors, Contacts	Weekly	FIST 2-10 App B
Inspect governor operation and working parts. Clean and lubricate.	Weekly	FIST 2-10 App B
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. Tighten door drive system points.	Monthly	FIST 2-10 App B
Check selector. Clean, adjust, and lubricate components as required.	Monthly	FIST 2-10 App B

Maintenance Task	Frequency	Reference
Check the oil level in the car and in the counterweight oil buffers. Add oil as required.	Monthly	FIST 2-10 App B
[Electric traction elevator maintenance/testing] Check the car telephone and alarm operations. Repair the alarm system if required. Check the operation of the limit and safety switches in hoistway and car. Check the motor brushes and commutators. Check the brushes for tension, seating, and wear (replace or adjust as required). Check commutators for finish, grooving, eccentricity, and mica level - clean, turn, or refinish as required. Check the car emergency light. Check the car ventilation system and heater. Initiate the Phase I firefighter recall service and check for proper operation to a minimum of two floors under Phase II service.	**[Monthly]**	FIST 2-10 Appendix B FIST 2-10 Section 4.3.1 PEB 55 Appendix 11
[Electric traction elevator maintenance/testing] Check for proper car leveling operation. Adjust if required. Check and clean the door switch contacts. Check the door speed control switches. Inspect the condition of resistors and mounting assemblies.	**[Monthly]**	

Maintenance Task	Frequency	Reference
Check car top and hoistway for loose covers, vanes, or components.		
Inspect the traveling cables for damage. Inspect the brake linings. Inspect all ropes for wear and lubrication (do not lubricate the governor rope) - replace or lubricate the ropes if required. Clean the governor and hoist ropes. Inspect the rope hitches, fastenings, and shackles - equalize ropes if warranted. Check the car position sensor drive wheel. Check decelerations, advances, and accelerations to ensure all cars are matched. Inspect all parts of the safeties and adjust clearance between the safety jaws and guide rails. Clean all parts and lubricate the pivot points.	Quarterly	FIST 2-10 App B
[Electric traction elevator maintenance/testing] Check all timers in the system and reset if necessary. Test all terminal limit switches. Lubricate the limit switch roller pins. Vacuum the carbon and dust. Clean the screens. Test the car emergency light for required illumination.	**[Semi-annual]**	FIST 2-10 Appendix B FIST 2-10 Section 4.3.1 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
Test and adjust dispatching, scheduling, and emergency service of the group supervisory control system (if equipped).		
Check for hoist rope wear, as well as rope length, lubrication, and tension. Replace, lubricate, or adjust the rope as required. Check the clearances for governor tension sheave, counterweight-to-buffer (with car at top landing), and compensation sheave to pit. Check governor sheave fastenings. Check all of the timers in the system and reset if necessary. Inspect guide rails, cams, fastenings, and counterweights in hoistways. Test all of the terminal limit switches. Lubricate the limit switch roller pins. Inspect the sheaves to verify that they are tight on the shafts, and sound their spokes and hubs with a hammer to inspect for cracks. Repair as necessary. Lubricate the guide shoe stems.	Semi-annual	FIST 2-10 App B
Remove, clean, and lubricate the brake cores. Inspect the brake linings for wear - clean or replace if necessary. Adjust the brakes to wear evenly if necessary.	Annual	FIST 2-10 App B
Inspect the armatures of hoist motor and motor-generator (if equipped). Check the electrical connections. Drain, flush, and refill the oil reservoirs. Lubricate the bearings.	Annual	FIST 2-10 App B

Maintenance Task	Frequency	Reference
Vacuum the carbon and dust. Clean the screens. Clean the guide rails with solvent to remove dirt, debris, or excess lubricant. Drain, flush, and refill the gearing lubricant. Test the car emergency light for required illumination. Test and adjust dispatching, scheduling, and emergency service of the group supervisory control system (if equipped). Check the compensation rope tension. Lubricate the sheave bearings and check for leaky seals. Clean the hoistway. Vacuum the dust from controllers and relays.		
[Electric elevator tests – 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, and final and normal stopping devices.] Check the electrical connections. Check the brushes for neutral settings and for proper quartering and spacing on the commutators. Reset if necessary.	**[Annual]**	FIST 2-10 Appendix B FIST 2-10 Section 4.3.1 PEB 55 Appendix 11
[Electric elevator tests – Every 5 years, complete the Category 5 test	**[5 year]**	

Maintenance Task	Frequency	Reference
requirements for electric elevators, which generally can be characterized as "rated-load/rated-speed," and involve the following equipment: oil buffers, safeties, governor, braking system emergency terminal stopping and speed-limiting devices' standby power operation, inner landing zone, power opening of doors, emergency stopping distance, leveling zone and leveling speed.]		
[Hydraulic elevator maintenance/testing] Ride in the car and observe operation of doors, leveling, smoothness, and door reopening devices at each landing. Listen for unusual noises in the car and in the hoistway. If excessive creeping is occurring, determine cause and correct. Check all car operating controls, lamps, and gongs. Replace burned-out lamps. Clean: Lamps and sensors in the car top controller, controller, selector, relay connectors, contacts.	**[Weekly]**	FIST 2-10 Appendix C FIST 2-10 Section 4.4.1 PEB 55 Appendix 11
Inspect and lubricate (as required) the machinery, pumps, piping, drive, valves, selector, and controller.	Weekly	FIST 2-10 App C
Clean: Drip pans (check oil levels of associated equipment) Door reopening device photo eye components Door tracks and sills Lamps and sensors in the car top controller Car top Machine room Pit	Weekly	FIST 2-10 App C

Maintenance Task	Frequency	Reference
Controller Selector Relay connectors Contacts Inspect plunger seals and correct excess leakage.		
Check and adjust the car door operation. Lubricate the hangers, rollers, gibs, linkages, and pivot points. Check and adjust door clearances, eccentrics, arm bearings, speed control switches, cables, clutches, chains, and belts. Tighten the door drive system points. Test mechanism - Observe for proper operation of motor and pump, oil lines, tank, controls, plunger, packing, etc. Check the oil tank level. Check the packing of valves and cylinder for leakage and tighten if necessary.	Monthly	FIST 2-10 App C
[Hydraulic elevator maintenance/testing] Check the car telephone and alarm operations. Repair the alarm system if required. Check the operation of limit and safety switches in hoistway and in/on the car. Check the car emergency light. Check the car ventilation system and heater. Initiate the Phase I firefighter recall service and check for proper operation to a minimum of two floors under Phase II service.	**[Monthly]**	FIST 2-10 Appendix C FIST 2-10 Section 4.4.1 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
[Hydraulic elevator maintenance/testing] Check the car for proper leveling operation. Adjust if required. Check and clean the door switch contacts. Check the door speed control switches. Check the condition of resistors and mounting assemblies. Check the car top and hoistway for loose covers, vanes, or components.	**[Quarterly]**	FIST 2-10 Appendix C FIST 2-10 Section 4.4.1 PEB 55 Appendix 11
Inspect the traveling cables for damage.	Quarterly	FIST 2-10 App C
[Hydraulic elevator maintenance/testing] Comprehensive inspection	**[Semi-annual]**	FIST 2-10 Appendix C FIST 2-10 Section 3.2 PEB 55 Appendix 11
[Hydraulic Elevator Tests – 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.] Conduct Category 1 tests (and Category 3 and 5 tests, if due). Test the car emergency light for required illumination.	**[Annual]**	FIST 2-10 Appendix C FIST 2-10 Section 4.3 PEB 55 Appendix 11

Maintenance Task	Frequency	Reference
Test a sample of the hydraulic fluid for viscosity, color, contamination, foaming, and other pertinent properties specified by the equipment manufacturer. Drain and replace the fluid if the tests show it does not meet the requirements of the equipment manufacturer. Clean the guide rails with solvent. Clean the hoistway. Vacuum the dust from controllers and relays.	Annual	FIST 2-10 App C
[Hydraulic Elevator Tests – 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 Appendix C FIST 2-10 Section 4.3 PEB 55 Appendix 11
[Hydraulic Elevator Tests – Complete the following Category 5 test requirements for hydraulic elevators, which involves the following equipment: oil buffer (if provided), safety (if provided), governor (if provided), coated ropes (if provided), rope fastening on pistons (if provided), and overspeed valve]	**[5 years]**	FIST 2-10 Appendix C FIST 2-10 Section 4.3 PEB 55 Appendix 11

34.0 Transformers

34.1 General

Transformers convert electrical power from one voltage level to another. Transformer reliability is essential to the continued delivery of the facility's services.

The maintenance schedule for transformers only pertains to transformers associated with critical equipment as defined in Section 1.3.2 of this document.

34.2 Instrument Transformers

34.2.1 General

Instrument transformers convert power system level voltages and currents to levels safe to feed meters and other low voltage and current devices. Voltage or potential transformers generally have output in the 240/120-Vac range, while current transformers have output in the 1- to 5-ampere range. Voltage transformers may be integral to other equipment or stand alone. Typically, current transformers are integral to other equipment (circuit breakers, transformers) but occasionally may be standalone (e.g., 500-kV switchyard at Grand Coulee).

Over the course of time, instrument transformers (particularly current transformers) may become overburdened with the addition of more devices in the secondary circuit. This may lead to saturation during a fault that may cause the relay to mis-operate. Periodical measuring of the secondary burden and comparing it to the rated burden will indicate if this is a problem.

Instrument transformer secondary wiring always should be checked for integrity after any work that may have disrupted these circuits.

Oil-filled instrument transformers may fail catastrophically and cause hazards to workers if not maintained properly. Any oil leak should trigger immediate testing and replacement planning.

34.2.2 Maintenance Schedule for CTs and PTs

Maintenance Task	Frequency	Reference
[Visually inspect PTs 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.]	**[Annually]**	Manufacturers Instruction
[Perform Visual Inspection of bushings for visible cracks, contamination, and oil level.]	**[Annually]**	FIST 3-30 Section 4.1.8 FIST 3-2 Section IV B
IR Scan bushings and all wirings	Annually	FIST 3-30 Sections 3.2.5, 4.1.8
[Test bushings for capacitance, dielectric loss, power factor/dissipation factor, **Partial discharge, insulation resistance.]**	**[3 years for U type]** **[6 years]**	FIST 3-30 Sections 4.1.8, 4.7, Table 17
[Perform in-depth bushing inspection for any carbon tracking, leaks, cracks]	**[6 years]**	FIST 3-30 Section 4.1.8
[Clean, repair chipped spots, remove and clean interphase barriers]	**[6 years]**	FIST 3-31
[Measure instrument transformer burdens.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.1 PEB 51
[Perform current transformer excitation test.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 6
[Perform insulation resistance tests.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.3 PEB 51 Table 1
[Verify CT and PT secondary circuits are grounded at only one point, and secondary grounding must be checked and verified.]	**[6 years]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.3

Maintenance Task	Frequency	Reference
{Verify that acceptable instrument transformer output signals (magnitude and phasing) are received at the protective relay.}	**[Upon commissioning,** **Every 6 years]** **{N}***	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.2 PEB 51 Table 1 PSMP
[Test instrument transformer secondary circuit polarity, phasing, and connections.]	**[6 years,** **or Upon commissioning of new/replacement instrument transformer or after major wiring modifications.]**	FIST 3-8 Section 3 Table 1 FIST 3-8 Section 5.4 PEB 51

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

34.3 Dry-Type Transformers

34.3.1 General

Dry-type power transformers are air cooled and have no liquid insulation. Typical applications include station service and excitation system transformers.

The maintenance schedule for dry-type power transformers pertains to transformers associated with critical equipment as defined in Section 1.3.2 of this document.

34.3.2 Maintenance Schedule for Dry-Type Power Transformers

Maintenance Task	Frequency	Reference
IR Scan.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
[Check the temperature rise (above ambient) if near or above nameplate rating, check for overloading.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
[Check the temperature alarm for proper operation.]	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29

Maintenance Task	Frequency	Reference
[Check enclosures and vaults/rooms for dirt accumulation on transformer surfaces and debris near or against enclosures.]	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
[Inspect windings for dirt- and heat-discolored insulation and structure problems.]	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
Check for loose connections.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
Check for carbon tracking and cracked, chipped, or loose insulators.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
Check and repair loose clamps, coil spacers, deteriorated barriers, and corroded or loose connections.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
Check fans for proper operation including controls, temperature switches, and alarms.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
Clean fan blades and filters if needed.	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
[Check pressure gauge on N_2 filled transformers; compare with weekly data sheets; never allow pressure to fall below 1 psi.]	**[Annually]**	FIST 3-30 Section 3.0 FIST 3-30 Section 3.1.1 PEB 55 Appendix 29
[Test Transformer]	**[When new before energizing and every 5 years]**	FIST 3-30 Section 4.7 PEB 29 PEB 55 Appendix 29
[Perform visual inspection of bushings for visible cracks, contamination, and oil level.]	**[Annually]**	FIST 3-30 Section 4.1.8 FIST 3-2 Section IV B
IR Scan bushings and all wirings	Annually	FIST 3-30 Sections 3.2.5, 4.1.8

Maintenance Task	Frequency	Reference
[Test bushings for capacitance, dielectric loss, power factor/dissipation factor, partial discharge, insulation resistance.]	**[5 years]**	FIST 3-30 Sections 4.1.8, 4.7, Table 17
[Perform in-depth bushing inspection for any carbon tracking, leaks, cracks]	**[5 years]**	FIST 3-30 Section 4.1.8
[Clean, repair chipped spots, remove and clean interphase barriers.]	**[5 years]**	FIST 3-31

34.4 Oil-Filled Power Transformers

34.4.1 General

Oil-filled power transformers rated 500 kVA and above generally deliver power to and from the main units of the facility—for example, generator step-up transformers. These transformers usually are located outside the building in a transformer bay or in a switchyard.

34.4.2 Maintenance Schedule for Oil-Filled Power Transformers

Maintenance Task	Frequency	Reference
[Inspect oil-filled transformers. Look carefully at temperature and oil level data sheets for a lack of variation in temperature, pressure, or oil level gauges, even with seasonal temperature and loading changes.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 4.1 PEB 55 Appendix 30
[Examine the DGA test results for signs of moisture in the oil.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 4.1 PEB 55 Appendix 30
[Check transformer tank for excessive corrosion and oil leaks]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 4.1 PEB 55 Appendix 30

Maintenance Task	Frequency	Reference
[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.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 4.1 PEB 55 Appendix 30
[Check the bushing oil level by viewing the oil-sight glass or the oil level gauge.]	**[Weekly]**	FIST 3-30 Section 4.1.8 PEB 55 Appendix 30
[Check the external porcelain for cracks and/or contamination. Look carefully for oil leaks.]	**[After 1 month of service and quarterly thereafter]**	FIST 3-30 Section 4.1.8 PEB 55 Appendix 30
[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.]**	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Check the oil flow indicator. **Check 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.]**	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Inspect and test the oil pumps.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Inspect piping and connections for leaks.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30

Maintenance Task	Frequency	Reference
[Override the temperature controller so that the pump starts.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Check the oil pump motor current on all three phases with an accurate ammeter.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Record this information for later comparison, especially if there is no oil flow indicator.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Carefully inspect all valves to make sure they are fully open. Listen for unusual noises.]	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Inspect cooling system. **Inspect and test the fans.** **Verify the temperature controller starts all the fans.]**	**[After 1 month of service and Annually thereafter]**	FIST 3-30 Section 3.2.6 PEB 55 Appendix 30
[Perform DGA.]	**[Annually]**	FIST 3-30 Section 3.1 FIST 3-30 Section 4.4 PEB 29 PEB 55 Appendix 31
Perform IR Scan of transformer	Annually	FIST 3-30 Section 3.1
[Perform Visual Inspection of bushings for visible cracks, contamination, and oil level.]	**[Annually]**	FIST 3-30 Section 4.1.8 FIST 3-2 Section IV B
IR Scan bushings and all wirings	Annually	FIST 3-30 Sections 3.2.5, 4.1.8
[Test Bushings for capacitance, dielectric loss, power factor/dissipation factor, partial discharge, insulation resistance.]	**[3 years for U type]** **[5 years]**	FIST 3-30 Sections 4.1.8, 4.7, Table 17 PEB 1

Maintenance Task	Frequency	Reference
[Perform In-depth bushing Inspection for any carbon tracking, leaks, cracks]	**[5 years]**	FIST 3-30 Section 4.1.8
[Clean, repair chipped spots, remove and clean interphase barriers]	**[5 years]**	FIST 3-31
[Test transformer gauges.]	**[5 years]**	FIST 3-30 Section 3.1
[Inspect pressure relief for leaks and indication for operation.]	**[Annually]**	FIST 3-30, Section 4.1.5
[Check the pressure gauge]	**[5 years]**	FIST 3-30 Section 4.2
[Inspect the gas pressure control components.]	**[5 years]**	FIST 3-30 Section 4.2.2
[Check conservator, inspect flange and look inside with a flashlight.]	**[5 years]**	FIST 3-30 Section 4.2 PEB 55 Appendix 30
[Test Thermometers and annunciation. **Functionally test the annunciator points, activate pumps/fans etc.]**	**[5 years]**	FIST 3-30 Section 4.1.3 PEB 55 Appendix 30
[Check the tank oil level indicators and alarm/tripping circuits. **Verify annunciator points and relays respond correctly.]**	**[5 years]**	FIST 3-30 Section 4.1.4 PEB 55 Appendix 30
[Check the pressure relief device for leaks at the gaskets.]	**[5 years]**	FIST 3-30 Section 4.1.5 PEB 55 Appendix 30
[Test Sudden Pressure Device.] **{N}***	**[5 years]**	FIST 3-30 Section 4.1.6 PEB 55 Appendix 30
[Test Buchholz Relay]	**[5 years]**	FIST 3-30 Section 4.1.7 PEB 55 Appendix 30
[Test Transformer]	**[When new before energizing and every 5 years]**	FIST 3-30 Section 4.7 PEB 29 PEB 55 Appendix 30

{N}* – Indicates that the task is a NERC requirement, and a frequency exists that the task must be performed within to maintain compliance with electric reliability standards.

35.0 Transformer Fire Suppression Systems

35.1 General

Reclamation generator step-up (GSU) transformers normally contain thousands of gallons of flammable transformer oil. Reclamation requires fire suppression for mineral oil-filled GSU transformers.

35.2 Maintenance Schedule for Transformer Fire Suppression Systems

Maintenance Task	Frequency	Reference
[Functionally test each transformer fire suppression system to ensure that: **• Detecting and initiating devices de-energizes 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.]**	**[Annually]**	FIST 3-32 Section 10 PEB 55 Appendix 31

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36.0 Calibration of Test Equipment

36.1 General

It is critical to ensure the proper operation and calibration of test equipment per the manufacturer's recommended schedule. If test equipment has not been calibrated to ensure accurate performance, then it may not be reliable to perform these critical functions accurately. Test equipment includes all equipment that is used to check the calibration or proper operation of other equipment. Calibration is required per the recommended interval in table 36.2 for equipment used to take measurements for test results to show compliance with regulatory requirements. These measurements need to be traceable to National Institute of Science and Technology (NIST) standards. Best practice recommends that instruments used to verify accuracy of plant equipment should be calibrated in accordance with the manufacturer's recommendations.

Most manufacturers recommend sending test equipment back to the manufacturer for calibration. However, this may not be necessary. For example, a craftsman can verify the accuracy of a relay test set with a calibrated multimeter or similar device to compare the output voltages and currents of the relay test set to the reading of the meter. The craftsman must use a multimeter or similar device that has been calibrated within the required interval. Such test procedures and/or equipment calibration certificates should be documented and filed for future reference.

36.2 Maintenance Schedule for Calibration of Test Equipment

Maintenance Task	Frequency	Reference
[Calibrate battery voltmeters.]	**[Annually]**	FIST 3-6 Section 1.4 PEB 55 Appendix 32
[Calibrate IR camera.]	**[Annually]**	FIST 3-6 Section 1.5 PEB 55 Appendix 32
[Calibrate test equipment that is used to check the calibration or proper operation of other equipment.]	**[Annually]**	PEB 55 Appendix 32

RECLAMATION
Managing Water in the West

RECLAMATION MANUAL TRANSMITTAL SHEET

Effective Date: **08/01/2022**

Release No. **014 (FIST)**

Ensure all employees needing this information are provided a copy of this release.

Reclamation Manual Release Number and Subject

FIST 4-1B, Maintenance Scheduling for Electrical Equipment

Summary of Changes

The following is the change in FIST 4-1B:

- **Section 20, Engine Generators, now references FIST 2-6 and 4-1A.**

NOTE: This Reclamation Manual release applies to all Reclamation employees. When an exclusive bargaining unit exists, changes to this release may be subject to the provisions of collective bargaining agreements.

Filing instructions

Remove Sheets	Insert Sheets
FIST 4-1B pp 1-161	**FIST 4-1B pp 1-161**

All Reclamation Manual releases are available at http://www.usbr.gov/recman/

Filed by: **Katherine J. Wheeler**

Date: **08/04/2022**