# Facilities Instructions, Standards and Techniques - Volume 4-1B

## Maintenance Scheduling for Electrical Equipment

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# Facilities Instructions, Standards, and Techniques - Volume 4-1B

## Maintenance Scheduling for Electrical Equipment


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# Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, Native Hawaiians, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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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 |
| VLF | Very Low Frequency |
| VRLA | Valve Regulated Lead Acid |
| XLPE | Cross (X) Linked Polyethylene |

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# 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 Assets

**Critical Assets.** Critical equipment or any system, asset, or component directly involved in the delivery of water or power whose failure could cause one or more of the following:

(1) a loss of control of water conveyance;
(2) load reduction or shutdown of power generation;
(3) a loss or reduction of transmission capability or capacity;
(4) serious personnel injury; and/or
(5) 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.

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**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.**

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## 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.

## 1.9 Monitored and Unmonitored Definition

A monitoring system for a component type consists of an internal or external scheme that monitors the components performance and produces an alert/alarm if an issue is detected. The monitoring system attributes applied to each component type must be consistent with the Maintenance Task(s) and Frequency listed in this document if it is used to extend the maintenance intervals beyond those specified for unmonitored components.

For example, a component type Maintenance Task is "Verify ventilation devices are operational" at a Frequency of "Monthly." This maintenance task would be considered "monitored" if the monitoring system automates this maintenance task by confirming the ventilation system is operational at a frequency of at least once per month. If the monitoring system does not meet this criterion, then it is considered "unmonitored."

# 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.<br><br>Verify that the expected audible alarms are heard and that all applicable indicating lights are lit.]** | **[Plant Rounds]** | PEB 43 |
| **[Check red light lit for lockout relay and circuit breaker coil continuity]** | Unmonitored:<br>**[Plant Rounds]**<br><br>Monitored[1]:<br>No periodic maintenance is required. | FIST 3-8 Table 1<br>FIST 3-8 Section 9.4 |

| | | |
|---|---|---|
| **[Functionally test annunciator and alarm circuits, including wiring, and connections, from beginning to end to ensure integrity of the total circuit]** | Periodic testing:<br><br>Unmonitored alarm circuits – **[10 Years]**<br><br>Monitored alarm circuits – No periodic maintenance required<br><br>Non-periodic testing:<br><br>**[When system is commissioned]**<br><br>and<br><br>**[After wiring changes to annunciator or alarm circuit]** | PEB 43<br>PSMP |

[1] Monitored lockout relay and circuit breaker trip coil includes real-time lockout and breaker trip coil continuity monitor and alarm.

## 2.3 Monitoring System Alerts/Alarms

### 2.3.1 General Requirements for Monitoring System Alarms

Monitoring system alarms must be reported within the interval in this section to a location where correction action can be initiated, unless otherwise noted in this document. NERC[1] requires that for monitoring systems used to justify extended maximum maintenance intervals and/or reduced maintenance activities the monitoring system alarm must be reported within 24 hours to a location where correction action can be initiated. For facilities and equipment not associated with this NERC requirement, monitoring system alarm must be reported within 1 week to a location where correction action can be initiated. This time interval will vary dependent on the risks associated with the equipment being monitored. In some cases, immediate notification may be necessary. However, the maximum time interval must not exceed the frequency listed under the unmonitored maintenance task(s) as listed in this document.

### 2.3.2 Maintenance Schedule for Monitoring System Alarms

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Verify monitoring system alarm path conveys alarm signals to a location[2] where corrective action can be initiated.}** | Periodic Testing:<br><br>**[10 Years] {N}***<br><br>Non-periodic testing:<br><br>**[When system is commissioned]**<br><br>and<br><br>**[after wiring changes to annunciator or alarm circuit]** | PEB 43<br>PSMP |
| **{Monitoring system alarm must be reported to a location[2] where correction action can be initiated.}** | **{24 hours} {N}***<br><br>Non-NERC:<br><br>**[Weekly]**[3] | PEB 43 |

| | | |
|---|---|---|
| **[Check the monitoring system for any alert indications and that the unit has power.]** | For monitoring systems that do not have external notification or alarming-<br><br>**[Weekly]**<br><br>For monitoring systems that have external notification or alarming-<br><br>No periodic maintenance required | Reclamation Standard Practice |

**{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.

1 – Alarm signals associated with NERC requirements noted with **{N}*** in this document.

2 – Typically achieved by connection of alarm to annunciation or similar system that is monitored by a staffed control center.

3 – Facilities and equipment not associated with the 24-hour reporting NERC requirement; monitoring system alarm must be reported within 1 week to a location where correction action can be initiated. This time interval may be less dependent on the risks associated with the equipment being monitored.

# 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: Annually]**<br><br>**[Indoors: 2 Years]** | PEB 44 |
| **[Perform infrared scan and thermal analysis of energized arresters.]** | **[Annually]** | FIST 4-13 Section 6.3.1<br>FIST 3-31 Section 10.2 |
| **[Check the apparent condition of the grounding conductors and their connections.]** | **[6 years]** | PEB 44 |
| **[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 condition of weatherheads and weatherhoods to determine that they remain in good condition.]** | **[6 years]** | PEB 44 |
| **[Conduct insulation resistance tests or power factor tests.]** | **[6 years]** | PEB 44<br>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 |
|---|---|---|
| **[Check for availability and physical condition of insulated tools and utensils.]** | **[Before each use]**<br><br>**[Annually]** | FIST 3-6 Section 2.8.1 |
| **[Check the hydrometer for cleanliness and lack of cracking of the rubber parts.]** | **[Before each use]**<br><br>**[Annually]** | FIST 3-6 Section 2.8.1 |
| **[Ensure egress from the battery room is clear at all times.]** | **[Monthly]** | 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 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Check availability and condition of all safety equipment, such as gloves, aprons, face shields, goggles, etc.]** | **[Monthly]** | FIST 3-6 Section 2.8.1 |
| **[Verify ventilation (airflow) devices (fans and vents) are operational.]** | Unmonitored:<br>**[Monthly]**<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 2.6.2 |
| **[Perform a visual inspection of the general appearance of battery, battery rack, and associated equipment.]** | **[Monthly]** | FIST 3-6 Section 2.8.1<br>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 |
| **[Verify that ventilation airflow monitoring and alarms are operational.]** | **[Annually]** | 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 |
| Infrared scan and thermal analysis of batteries, connections, and battery chargers | Annually<br><br>During battery capacity testing | FIST 4-13 Section 6.3.1 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{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 |

## 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, if polarity to ground voltmeter is installed, check voltage from each polarity to ground.]** | **[Plant rounds]** | FIST 3-6 Section 3.5.2.2 |
| **{Verify no unintentional grounds on the battery system.}** | Unmonitored: **[Monthly] {N}***<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 3.5.9.1<br>PSMP<br>PRCB 11-6 |
| **[Check and record the ambient temperature.]** | Unmonitored: **[Monthly]**<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Section 3.5.6 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Check the electrolyte level in every cell.}** | Unmonitored:<br>**[Monthly] {N}***<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 3.5.6<br>PRCB 11-6 |
| **[Check every cell for electrolyte leaks and cracks in cell jars.]** | **[Monthly]** | FIST 3-6 Section 3.5.6 |
| **{Measure and record the overall float voltage with charger in service across the battery terminals.}** | Unmonitored:<br>**[Quarterly] {N}***<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Sections 3.5.2.2, and 3.6.2<br>PSMP<br>PRCB 11-6 |
| **[Measure and record the float voltage on all individual cells to the nearest 0.01V with a digital voltmeter.]** | Unmonitored:<br>**[Quarterly]**<br><br>Monitored**:<br>No periodic maintenance required<br><br>Non-Periodic:<br>**[Upon commissioning or upon complete disassembly and reassembly]**<br><br>**[During equalizing charge]**<br><br>**[When performing battery capacity test]** | FIST 3-6 Sections 3.5.2.1, 3.5.2.2, 3.6.2 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Measure and record specific gravity readings of all cells.]** | Unmonitored:<br>**[Quarterly]**<br><br>Monitored **:<br>**[Annually]**<br><br>Non-periodic:<br>**[After equalizing charge and 15 minutes after heavy gassing stops]**<br><br>**[During equalizing charge]**<br><br>**[Prior to performing battery capacity test]** | FIST 3-6 Sections 3.5.3.5, 3.5.3.6, and 3.6.2 |
| **[Measure and record electrolyte 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.]** | Unmonitored:<br>**[Quarterly]**<br><br>Monitored**:<br>**[Annually]**<br><br>Non-periodic<br>**[After equalizing charge, about 15 minutes after heavy gassing stops]**<br><br>**[During equalizing charge]**<br><br>**[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}**<br>Measure and record battery float charging current. | Unmonitored:<br>**[Quarterly] {N}***<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Section 3.5.8.1<br>PSMP<br>PRCB 11-6 |
| **{Perform a detailed visual inspection of the battery, battery rack, and associated equipment.}** | **[Annually] {N}*** | FIST 3-6 Section 3.5.6.1<br>PSMP<br>PRCB 11-6 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Check condition of the vent plugs, flame arrestors, and dust caps.]** | **[Annually]** | FIST 3-6 Section 3.5.6 |
| **[Check for corrosion at terminals and connectors.]** | **[Annually]** | FIST 3-6 Section 3.5.6 |
| **[Document the sedimentation found within the batteries.]** | **[Annually]** | FIST 3-6 Section 3.5.6 |
| **[Measure and record temperature readings of each individual cell and jumpers in the system and record the results.]**<br><br>Monitor negative post for internal cell temperature. | Unmonitored:<br>**[Annually]**<br><br>Monitored**:<br>No periodic measurement required<br><br>Non-periodic:<br>**[When performing battery capacity test]** | FIST 3-6 Section 3.5.4.2 |
| **{Measure and record micro-ohm resistance values for all connections.}** Both cell to cell and terminal connectors | Unmonitored:<br>**[Annually]** **{N}***<br><br>Monitored:<br>No periodic maintenance required<br><br>Non-periodic:<br>**[When performing battery capacity test]** | FIST 3-6 Section 3.5.5.4<br>PSMP<br>PRCB 11-6 |
| **[Using a micro-ohm meter, measure and record the resistance of each connection as a baseline (basis micro-ohms).]** | Non-periodic:<br>**[Upon commissioning or upon complete disassembly and reassembly]** | FIST 3-6 Sections 3.5.5.3 |
| **{Perform battery capacity test and record individual cell and battery bank results.}** | **[5 years]**[1] **{N}***<br><br>Non-periodic:<br>**{Upon Commissioning}** | FIST 3-6 Sections 3.6 and 3.6.2<br>PSMP<br>PRCB 11-6 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform acceptance testing and record individual cell and battery bank results.]** | Non-periodic: **[After the battery has been on a float charge for a minimum of 12 weeks without deep discharging, but no later than 1 year after installation.]** | FIST 3-6 Section 3.6.1 |
| **[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 Commissioning, modification, or damage.]** | FIST 3-6 Section 3.5.1 |
| **[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.

** – Specific gravity and electrolyte temperature measurements test frequencies can be extended from Quarterly to Annually if monitor system includes following points: cell temperature scans (IR or negative post temperature), battery bank continuity measurement, individual cell voltage measurements, battery bank float voltage measurement, and ambient temperature measurements or these points are manually measured monthly.

**{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 distribution panel to determine if the battery is being charged at the proper float voltage, if polarity to ground voltmeter is installed, check voltage from each polarity to ground.]** | **[Plant rounds]** | FIST 3-6 Section 4.5.2.2 |
| **{Verify no unintentional grounds on the battery system.}** | Unmonitored:<br>**[Monthly] {N}***<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 4.5.8.1<br>PSMP<br>PRCB 11-6 |
| **[Check and record the ambient temperature.]** | Unmonitored:<br>**[Monthly]**<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Section 4.5.6 |
| **{Check for electrolyte leaks and cover integrity, take corrective action, if needed.}** | **[Monthly] {N}*** | FIST 3-6 Section 4.5.6<br>PRCB 11-6 |
| **{Measure and record the overall float voltage with charger in service across the battery terminals.}** | Unmonitored:<br>**[Quarterly] {N}***<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Section 4.5.2.2<br>PSMP<br>PRCB 11-6 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Verify battery bank continuity}**<br><br>Measure and record battery float charging current. | Unmonitored:<br>**[Quarterly]** **{N}***<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Section 4.5.7.1<br>PSMP<br>PRCB 11-6 |
| **[Measure and record the float voltage on all individual cells to the nearest 0.01V with a digital voltmeter.]** | Unmonitored:<br>**[Quarterly]**<br><br>Monitored**:<br>No periodic maintenance required<br><br>Non-Periodic:<br>**[Upon commissioning or upon complete disassembly and reassembly]**<br><br>**[During equalizing charge]**<br><br>**[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 individual cell in the system and record the results.]**<br><br>Monitor negative post for internal cell temperature. | Unmonitored:<br>**[Quarterly]**<br><br>Monitored **:<br>No periodic maintenance required<br><br>Non-periodic:<br>**[24 hours after Commissioning, or complete disassemble and re-assemble, with system on a float and when the temperatures have stabilized]**<br><br>**[When performing battery capacity test]** | FIST 3-6 Sections 4.5.3.1 and 4.5.3.2 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Measure and record the internal resistance on each cell.}** | Unmonitored:<br>**[Quarterly] {N}***<br><br>Monitored **:<br>No periodic maintenance required<br><br>Non-periodic:<br><br>**[After Commissioning, or complete disassemble and re-assemble (1-3 days on float)]** | FIST 3-6 Sections 4.5.5.1 and 4.5.5.2<br>PSMP<br>PRCB 11-6 |
| **{Perform a detailed visual inspection of the battery, battery rack, and associated equipment.}** | **[Annually] {N}*** | FIST 3-6 Section 4.5.6.1<br>PSMP<br>PRCB 11-6 |
| **[Check for corrosion at terminals and connectors.]** | **[Annually]** | FIST 3-6 Section 4.5.6 |
| **{Perform battery capacity test and record individual cell and battery bank results.}** | Unmonitored:<br>**[Annually]**[1] **{N}***<br><br>Monitored **:<br>**[2 years] {N}*** | FIST 3-6 Sections 4.6, 4.6.2.1, and 4.6.2.2<br>PSMP<br>PRCB 11-6 |
| **{Measure and record micro-ohm resistance values for all connections.}**<br><br>Both cell to cell and terminal connectors | Unmonitored:<br>**[Annually] {N}***<br><br>Monitored:<br>No periodic maintenance required<br><br>Non-periodic:<br>**[When performing battery capacity test or upon complete disassembly and reassembly]** | FIST 3-6 Sections 4.5.4.1, 4.5.4.2, and 4.6<br>PSMP<br>PRCB 11-6 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[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 Section 4.5.4.1 |
| **[Perform acceptance testing and record individual cell and battery bank results.]** | 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 |
| **[Post a battery data card form POM-158 in a conspicuous location near the battery when battery is installed.]** | Non-periodic: **[Upon commissioning, 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 |

[1] 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.

** – Battery capacity testing frequency can be extended from annually to 2 years if monitoring includes the following points: ambient temperature readings, battery float voltage, battery float current, cell voltages, cell temperature readings, and cell internal resistance readings or these points are manually measured monthly.

**{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 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| {Compare data collected to the baseline or previous results.} | {Each maintenance interval} | FIST 3-6 Section 5.5.1 |
| {Verify no unintentional grounds on the battery system.} | Unmonitored:<br>**[Monthly]** {N}*<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 5.5.9.1<br>PSMP<br>PRCB 11-6 |
| **[Check the voltmeter on the distribution panel to determine if the battery is being charged at the proper float voltage, if polarity to ground voltmeter is installed, check voltage from each polarity to ground.]** | **[Plant rounds]** | FIST 3-6 Section 5.5.2.2 |
| **[Check and record the ambient temperature.]** | **[Monthly]** | FIST 3-6 Section 5.5.5 |
| **[Check for electrolyte leaks and cracks in cells, take corrective action if found.]** | **[Monthly]** | FIST 3-6 Section 5.5.5 |
| {Check all the electrolyte levels.} | Unmonitored:<br>**[Monthly]** {N}*<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 5.5.5<br>PRCB 11-6 |
| **[Verify that the mineral oil level is approximately one-quarter inch.]** | **[Monthly]** | FIST 3-6 Section 5.5.5 |
| {Perform a detailed visual inspection of the battery, battery rack and associated equipment.} | **[Quarterly]** {N}* | FIST 3-6 Section 5.5.5.1<br>PSMP<br>PRCB 11-6 |
| **[Check for corrosion at terminals and connectors.]** | **[Quarterly]** | FIST 3-6 Section 5.5.5 |
| **[Check condition of the vent plugs, flame arrestors, and dust caps.]** | **[Quarterly]** | FIST 3-6 Section 5.5.5 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Measure and record the overall float voltage with charger in service across the battery terminals.}** | Unmonitored:<br>**[Quarterly] {N}***<br><br>Monitored:<br>No periodic maintenance required | FIST 3-6 Section 5.5.2.2<br>PSMP<br>PRCB 11-6 |
| **{Verify battery bank continuity.}**<br>Measuring and recording float current | Unmonitored:<br>**[Quarterly] {N}***<br><br>Monitored**:<br>No periodic maintenance required | FIST 3-6 Section 5.5.8.1<br>PSMP<br>PRCB 11-6 |
| **[Measure and record the float voltage on all individual cells to the nearest 0.01 volts with a digital voltmeter.]** | Unmonitored:<br>**[Quarterly]**<br><br>Monitored:<br>**[Annually]**<br><br>Non-Periodic:<br>**[Upon commissioning or upon complete disassembly and reassembly**<br><br>**[During equalizing charge]**<br><br>**[When performing battery capacity test]** | FIST 3-6 Sections 5.5.2.1, |
| **[Measure and record electrolyte 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.]** | Unmonitored:<br>**[Annually]**<br><br>Monitored:<br>**[Annually]**<br><br>Non periodic:<br>**[When performing battery capacity test]** | FIST 3-6 Section 5.5.3.1 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Measure and record micro-ohm resistance values for all connections.}** Both cell to cell and terminal connectors | Unmonitored:<br>**[Annually] {N}***<br><br>Monitored:<br>No periodic maintenance required.<br><br>Non-periodic:<br><br>**[When performing battery capacity test]** | FIST 3-6 Sections 5.5.4.1, 5.5.4.2<br>PSMP<br>PRCB 11-6 |
| **{Perform battery capacity testing.}** | **[5 years]**[1] **{N}*** | FIST 3-6 Sections 5.6.1, 5.6.2<br>PSMP<br>PRCB 11-6 |
| **[Using a micro-ohm meter, measure and record the resistance of each connection as a baseline (basis micro-ohms).]** | Non-periodic:<br>**[Upon commissioning or upon complete disassembly and reassembly]** | FIST 3-6 Section 5.5.4.1 |
| **[Perform acceptance testing and record individual cell and battery bank results.]** | Non-periodic:<br>**[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 |
| **[Post a battery data card from POM-159 in a conspicuous location near the battery.]** | Non-periodic:<br>**[Upon Commissioning, 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 |

[1] 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 |
|---|---|---|
| **[For parallel chargers, check that each charger will carry the total plant load.]** | **[Annually]** | FIST 3-6 Section 6.3.1 |
| **{Verify float voltage of battery charger}** | **[Annually] {N}*** | FIST 3-6 Section 6.3.1<br>PSMP<br>PRCB 11-6 |
| **[Ensure float and equalize settings are correctly set.]**<br>Verify the accuracy of the charger/panel voltage meter. Balance load between chargers, if available. | **[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 |
| **[Ensure the maximum AC ripple voltage does not exceed manufacturer's specifications.]** | **[Annually]** | FIST 3-6 Section 6.3.1 |
| **[Verify and test associated alarms and settings.]** | **[2 years]** | FIST 3-6 Section 6.3.1 |
| Check connection integrity. | 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 |
| **[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 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Verify monitoring system cell voltages to manual readings at the battery cells.]** | **[Annually]** | FIST 3-6 Section 7.3.2.2 |
| **[Verify monitoring system overall battery current.]** | **[Annually]**<br><br>**Non-periodic: [When performing battery capacity testing[1]]** | FIST 3-6 Section 7.3.2.2 |
| **[Verify monitoring system cell temperature.]** | **[Annually]**<br><br>Non-periodic: **[When performing battery capacity testing]** | 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 |
| **[Verify monitoring system cell connection resistance.]** | **[2 years]**<br><br>Non-periodic: **[When performing battery capacity testing]** | FIST 3-6 Section 7.3.2.2 |
| **[Verify monitoring system cell fluid levels, if applicable.]** | **[2 years]**<br><br>Non-periodic: **[When performing battery capacity testing]** | FIST 3-6 Section 7.3.2.2 |
| **[Verify monitoring system cell specific gravity, if applicable.]** | **[2 years]**<br><br>Non-periodic: **[When performing battery capacity testing]** | FIST 3-6 Section 7.3.2.2 |

[1] 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.

# 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 |
|---|---|---|
| Perform IR Scan and thermal analysis on 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.]** | **[6 years]** | Manufacturers' Maintenance guide |
| **[Tighten all bus and ground connections and inspect for heating.**<br><br>**Refinish contact surfaces if they have been overheating.**<br><br>**Inspect ground cable to see that it is not loose or broken.]** | **[6 years]** | Manufacturers' Maintenance guide |
| **[Perform Insulation Test]** (Power frequency dielectric loss, DC insulation resistance, or power factor) | **[6 years]** | FIST 3-1<br>Manufacturers' Maintenance guide |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Industry Standards**] | Periodic:<br>**[6 years]**<br><br>Non-Periodic:<br>**[Upon assembly/reassembly of bolted connections.]**<br><br>**[If abnormal IR scan is observed]** | |

# 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 |
|---|---|---|
| **[Perform IR Scan and thermal analysis of cables]** | **[Annually]** | FIST 4-13 Section 6.3.1 |
| **[DC High-Potential (proof/withstand), DC-Step, or DC-Ramp test.]**<br>Exception: Do not test XLPE (cross-linked polyethylene) cables using high-voltage direct-current (DC) in “wet” location(s). | Unmonitored:<br>**[6 Years]**<br><br>Monitored[2]:<br>**[12 Years]** | FIST 3-1 Section 46 |
| Perform testing for XLPE cables in "wet" locations[1].<br><br>**[Partial Discharge Test]**<br>or<br>**[Very Low Frequency (VLF) Test]** | Partial Discharge Test<br>Unmonitored:<br>**[Annually]**<br><br>Monitored[2]:<br>No Periodic Maintenance Required<br>or<br>VLF Test<br>**[6 years]** | |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Industry Standards]** | Periodic:<br>**[6 years]**<br><br>Non-Periodic:<br>**[Upon assembly/reassembly of bolted connections.]**<br><br>**[If abnormal IR scan is observed]** | |
| **[Perform a shield-continuity test on each power cable by ohmmeter method.]** | Non-Periodic:<br>**[Upon commissioning or retermination of cables.]** | |

[1] - "Wet" locations - Per NFPA 70: A location that is one or more of the following:
- Unprotected and exposed to weather
- Subject to saturation with water and other liquids
- Underground
- In concrete slabs or masonry in direct contact with the earth

[2] - Continuous on-line monitoring

# 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)<br>FIST 5-12 Section 7.2<br>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<br>FIST 5-12 Section 15 Table 2<br>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)<br>FIST 5-12 Section 15 Table 2 |
| **[Perform simulated $CO_2$ emergency evacuation drill.]** | **[Annually]** | FIST 5-12 Section 15 Table 2<br>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<br>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 |
|---|---|---|
| **[Perform infrared scan of casing and terminals of all MCCBs. Perform thermal analysis using data collected.]**<br><br>In instances where incident energy is too high to allow for panel removal, perform scan with front panel installed. | **[Annually]** | FIST 3-16 Section 3.3.2 |
| **[Manual operation of all MCCBs]** | **[2 Years]** | FIST 3-16 Section 3.2.2 |
| **[Visual inspection of Critical MCCBs]**<br><br>When feasible, use a torquing screwdriver to check connection torque. | **[4 years]** | FIST 3-16 Section 3.2.1 |
| **[Review equipment ratings and coordination study]** | **[5 Years]**[1] | FIST 3-16 Section 3.3.1 |
| **[Perform visual inspection of non-critical MCCBs]**<br><br>When feasible, use a torquing screwdriver to check connection torque. | **[12 Years]** | FIST 3-16 Section 3.2.1 |
| **[Test/Replace Critical MCCBs. Test includes: Inverse-time over current and/or instantaneous trip, insulation resistance, and contact resistance test of critical MCCBs.]** | **[Test at 24 years and every 6 years after]**<br><br>**[The age shall not exceed 36 years]** | FIST 3-16 Section 3.2.3 |
| **[Inverse-time over current and/or instantaneous trip, insultation resistance, and contact resistance test of non-critical MCCBs]** | **[25 Years]**<br><br>Replace as needed | FIST 3-16 Section 3.2.3 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

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

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform visual inspection in accordance with FIST and manufacture's O&M manual]** | **[Annually]** | FIST 3-16 Section 4.2.1 |
| **[Infrared scan and thermal Analysis]** | **[Annually]** | FIST 3-16 Section 4.2.8<br>FIST 4-13 |
| **[Manual operation]** | **[2 Years]** | FIST 3-16 Section 4.2.3 |
| **[Perform preventive maintenance in accordance with FIST and manufacturer's O&M manual]** | **[Outdoors: 3 years]**<br><br>**[Indoors: 6 years]** | FIST 3-16 Section 4.2.2 |
| **[Timing, Insulation Resistance, and Contact Resistance Tests]** | **[Outdoors: 3 years]**<br><br>**[Indoors: 6 years]** | FIST 3-16 Section 4.2.4 |
| **[Review equipment ratings and coordination study]** | **[5 Years]**[1] | FIST 3-16 Section 4.2.7 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

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

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform visual inspection in accordance with FIST and manufacture's O&M manual]** | **[Annually]** | FIST 3-16 Section 5.2.1 |
| **[Infrared scan and thermal analysis]** | **[Annually]** | FIST 3-16 Section 5.2.10 |
| **[Perform preventive maintenance in accordance with FIST and manufacturer's O&M manual]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 5.2.2 |
| **[Manual operation]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 5.2.3 |
| **[Timing, Motion Analysis, Insulation Resistance, Contact Resistance Tests]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 5.2.6 |
| **[Breaker control functional testing]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 2.7 |
| **[Review equipment ratings and coordination study]** | **[5 years]**[1] | FIST 3-16 Section 5.2.9 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

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

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform visual inspection in accordance with FIST and manufacture's O&M manual]** | **[Annually]** | FIST 3-16 Section 6.2.1 |
| Infrared scan and thermal analysis | Outdoors: 3 years<br>Indoors: 6 years | FIST 3-16 Section 6.2.10 |
| **[Manual operation]** | **[2 years]** | FIST 3-16 Section 6.2.3 |
| **[Perform preventive maintenance in accordance with FIST and manufacturer's O&M manual]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 6.2.2 |
| **[Timing, Contact Resistance, Insulation Resistance, and Vacuum-Integrity Tests]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 6.2.6 |
| **[Breaker control functional testing]** | **[Outdoors: 3 years]**<br>**[Indoors: 6 years]** | FIST 3-16 Section 2.7 |
| **[Review equipment ratings and coordination study]** | **[5 years]**[1] | FIST 3-16 Section 6.2.9 |
| Contact-erosion indicator check | Per Manufacturer O&M manual | FIST 3-16 Section 6.3.1 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

## 9.6 Maintenance Schedule for Medium and High Voltage Oil Circuit Breakers

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Inspect and test insulation oil]** | **[Annually]** | FIST 3-16 Section 7.2.1 |
| **[Perform visual inspection in accordance with FIST and manufacture's O&M manual]** | **[Annually]** | FIST 3-16 Section 7.2.2 |
| **[Infrared scan and thermal analysis]** | **[Annually]** | FIST 3-16 Section 7.2.10 |
| **[Review equipment ratings and coordination study]** | **[5 years]**[1] | FIST 3-16 Section 7.2.10 |
| **[Perform preventive maintenance in accordance with FIST and manufacturer's O&M manual]** | **[6 years]** | FIST 3-16 Section 7.2.3 |
| **[Manual operation]** | **[6 years]** | FIST 3-16 Section 7.2.4 |
| **[Timing, Motion Analysis, Insulation Resistance, and Contact Resistance Tests]** | **[6 years]** | FIST 3-16 Section 7.2.7 |
| **[Breaker control functional testing]** | **[6 years]** | FIST 3-16 Section 2.7 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

## 9.7 Maintenance Schedule for Medium and High Voltage $SF_6$ Circuit Breakers

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform visual inspection in accordance with FIST and manufacture's O&M manual]** | **[Annually]** | FIST 3-16 Section 8.2.1 |
| **[SF6 gas analysis]** | **[Annually]** | FIST 3-16 Section 8.2.4 |
| **[Infrared scan and thermal analysis]** | **[Annually]** | FIST 4-13 |
| **[Review equipment ratings and coordination study]** | **[5 years]**[1] | FIST 3-16 Section 8.2.11 |
| **[Perform preventive maintenance in accordance with FIST and manufacturer's O&M manual]** | **[6 years]** | FIST 3-16 Section 8.2.3 |
| **[Manual operation]** | **[6 years]** | FIST 3-16 Section 8.2.5 |
| **[Timing and Motion Analysis]** | **[6 years]** | FIST 3-16 Section 8.2.8 |
| **[Breaker control functional testing]** | **[6 years]** | FIST 3-16 Section 2.7 |
| Contact resistance test | 6 years | FIST 3-16 Section 8.2.7 |
| **[Internal circuit breaker inspection or overhaul]** | **[15 years, 5,000 operations, 3 high current interruptions, or in accordance with manufacturer's recommendations]** | FIST 3-16 Section 8.2.12<br>Manufacturer's O&M manuals |
| Radiography Inspection | 12 years or if problems are identified by other tests | FIST 3-16 Section 8.2.14<br>FIST 3-16 Section 8.3.3 |
| **[Track and report SF6 gas use for environmental compliance]** | **[Upon adding additional gas to system or finding of loss of gas]** | FAC 04-13 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

# 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 |
|---|---|---|
| **[Visually inspect for bulged case, chipped or cracked bushings, loose connections, and for oil leaks.**<br><br>**Check oil level of the base box by means of the oil gauge.**<br><br>**Clean bushings.]** | **[6 years]** | |
| **[Perform power factor test on CCVT]** | **[6 years]** | FIST 3-25 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Verify that acceptable instrument transformer output signals (magnitude, phasing and polarity) are provided to the protective relay.}** | Unmonitored and internal monitored relays:<br>**[10 years] {N}***<br><br>External Monitored relays without independent[1] instrument transformers:<br>**[10 year] {N}***<br><br>External Monitored relays with independent1 instrument transformers: No periodic maintenance required<br><br>**[Upon commissioning and after wiring modifications]** | FIST 3-8 Section 8.3<br>FIST 3-8 Section 5.2<br>PEB 52<br>PSMP<br>PRCB 11-6 |

**{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.

[1]– External monitored relays defined in section 26.4 Maintenance Schedule for Microprocessor Relays. Independent instrument transformers are defined as 2 or more instrument transformer whose output signals can be compared to detect for excessive error. Examples include comparison of 2 instrument transformers on the same phase and bus, comparison of same phase differential current transformers, comparison of 3-phase current transformers on a delta connected bus, or comparison of instrument transformers on either side of a power transformer.

# 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<br>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<br>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<br>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 actuating mechanism of the limit switch** | **[Annually]** | FIST 4-1A Section 6.5<br>PEB 55 Appendix 11 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **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<br>PEB 55 Appendix 11 |
| **[Visually examine resistor tubes for cracks, loose bands and connections, and broken resistance wire.<br><br>Clean resistor banks if dirty.]** | **[Annually]** | FIST 4-1A Section 6.5 Table 2<br>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.<br><br>Grease bearings if not of the sealed type. Test motor insulation.]** | **[Annually]** | FIST 4-1A Section 6.10.7<br>PEB 55 Appendix 11 |
| **[Check motor brushes for wear and slip rings for pitting.<br><br>Examine brushes for length and fit.<br><br>Replace one at a time if badly worn.]** | **[Annually]** | FIST 4-1A Section 6.10.7<br>PEB 55 Appendix 11 |
| **[Inspect commutators for wear, flat spots, high bars discoloration, or ridging. Never touch the commutator with your finger.<br><br>Check connections to brushes.<br><br>Look for signs of excessive heat.<br><br>Re-torque to manufacturer's recommendations as required.** | **[Annually]** | FIST 4-1A Section 6.10.7<br>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<br>PEB 55 Appendix 11 |
| **[Inspect electrical equipment.**<br><br>**Check controller contacts for signs of pitting or any other deterioration.**<br><br>**Examine the controller for burned contacts or signs of overheating.**<br><br>**Check for excessive wear or looseness of control levers.**<br><br>**Vacuum and clean the controller if contaminated with dust and dirt.**<br><br>**Lubricate moving parts as needed.**<br><br>**Check strain relief on pendent.**<br><br>**Check that required control markings are displayed and legible.]** | **[Annually]** | FIST 4-1A Section 6.10.7<br>PEB 55 Appendix 11 |
| **[Warning devices.**<br><br>**Check operation of hoist upper, lower, and travel limit switches.**<br><br>**Check electrical contacts for signs of pitting or any other deterioration.**<br><br>**Check levers and cams for adequate lubrication and excessive wear.**<br><br>**Verify main disconnect and cab disconnect or breaker meet all code requirements.]** | **[Annually]** | FIST 4-1A Section 6.10.7<br>PEB 55 Appendix 11 |
| **[Bridge and trolley conductors and collectors.** | **[Annually]** | FIST 4-1A Section 6.10.7<br>PEB 55 Appendix 11 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| Check the contact surfaces of open conductors and collectors for signs of arcing damage, pitting, and corrosion.<br><br>Check condition of insulators.<br><br>Clean as required. Check that festoon-type conductor cables move freely with bridge and trolley movement.<br><br>Check the condition of insulation and for kinking in cable.<br><br>Check that all guards are in place and secure.] | | |

# 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:<br>(1) Excessive checking, cracking, or splitting; especially deep checks in full-length treated poles showing white wood.<br>(2) Woodpecker holes and evidence of insect colonies.<br>(3) Excessive shell decay above ground – note degree.<br>(4) Lightning damage.<br>(5) Damaged or corroded guying.<br>(6) Damaged bracing.<br>(7) If in through-drilled poles the backfill extends above the drilled section – REMOVE!<br>(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<br>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<br>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 megavar 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<br>PEB 55 Appendix 13<br>NFPA 31 |
| **[A 1.5-hour functional test shall be conducted on every required battery-powered emergency lighting system.]** | **[Annually]** | PEB 34<br>PEB 55 Appendix 13<br>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<br>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 Design Rating Review, Arc Flash Hazard Analysis, And Review of Protective Relaying

## 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 Facility Design Rating Review, Arc Flash Hazard Analysis, or Review of Protective Relaying, contact the Power System Analysis and Control Group (86-68440) at 303-445-2300.

## 17.2 Maintenance Schedule for Facility Design Rating Review

A 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. Equipment review includes all main power train equipment in the "water to wire" path for each generator including:

- Generator (electrical components)
- Medium voltage segregated or isolated phase bus
- Generator breaker, disconnects and associated components
- Generator step up transformers
- Station service transformers
- Bushings
- Current transformers
- Protective relays
- Overhead conductors and jumpers
- Medium and High voltage cables
- Surge/lightning arresters
- Neutral grounding equipment
- Disconnect switches and fuses

Including mechanical limitations in the Facility Design Rating review is not required under the NERC standard, it is Reclamation's best practice especially if known changes to equipment have been made since the last assessment, including:

- Generator (mechanical components)
- Turbine
- Turbine shaft and flanges
- Intermediate shaft and flanges (if applicable)

Equipment may also include the transmission equipment if owned by Reclamation:

- High voltage bus
- High voltage disconnect switches
- High voltage circuit breakers
- Line conductors
- System transformers
- Shunt reactors
- Switchyard conductors
- Switchyard current transformers
- Switchyard and transmission line protective relaying.

This review shall include the tasks identified in the table below:

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Evaluate equipment continuous current capability for existing installation and identify the most limiting individual equipment in the powertrain.}[1]** | **[5 years][2]** | PRCB 6-5, Attach A (FAC-008-3) |
| **[Evaluate nameplate ratings for fault current analysis, verification of interrupting short circuit withstand capabilities, and insulation coordination of electrical equipment.]** | **[5 years][2]** | PEB 44<br>PEB 46<br>PEB 55 Appendix 15 |
| **[Review sizing of personal protective grounds based on available fault current for grounding locations.  Update list of the maximum fault currents at each facility or location where Reclamation employees apply personal protective grounds.]** | **[5 years][2]** | FIST 5-1, section 4.2 |

[1]NERC Associated task, however there is no NERC interval associated with the task.

[2]Non-NERC qualifying facilities may be allowed to revalidate a previous Facility Design Rating Review at the 5-year interval if it can be confirmed by a qualified engineer that no significant changes have been made to main power train equipment and no significant changes have been made to the system interconnection. (Note: a smaller study may be required to verify the significance/impact of any changes to allow revalidation of previous study at 5-year interval.) If a previous study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

## 17.3 Maintenance Schedule for Review of Protective Relaying

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Evaluate and update relay settings to include a protection system coordination study with updated fault and load study results.}** | **[5 years] {N}*** | FIST 3-8, Section 4.1<br>FIST 6-4, Section 4<br>PRC-027-1 |
| **[Evaluate burden of instrument transformers used for differential protective relaying.]** | **[6 years]** | FIST 3-8, section 5.1 |
| **{Review protective relay settings to ensure compliance with applicable regulatory standard requirements.}** | **[5 years] {N}*** | PRCB 11-15 (PRC-019-2),<br>PRCB 11-18 (PRC-023-4),<br>PRCB 11-24 (PRC-024-3),<br>PRCB 11-25 (PRC-025-2),<br>PRCB 11-27 (PRC-027-1) |

**{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.

## 17.4 Maintenance Schedule for Arc Flash Hazard Analysis

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Perform an Incident Energy Analysis (Arc-Flash Study)}** | **[5 years]**[1] | FIST 5-14 Section 10.1 |
| **[Perform an equipment duty evaluation and protective device coordination study.]** | **[5 years]**[1] | FIST 5-14 Section 10.1 |

[1] Non-NERC qualifying facilities may be allowed to revalidate a previous arc flash study at the 5-year interval if a qualified engineer (as defined in FIST 5-14 section 10.2) evaluates there have been no significant changes to the electrical system (including the distribution system) or system interconnection which would affect the arc flash results. If the study is revalidated at the 5-year interval, a new study is required at the 10-year interval.

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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.]**<br>Portable extinguishers shall be inspected monthly for:<br>(1) The extinguisher shall be in its designated place.<br>(2) Access to, or visibility of, the extinguisher shall not be obstructed.<br>(3) The operation instructions on the extinguisher nameplate shall be legible and face outward.<br>(4) Any seals or tamper indicators that are broken or missing shall be replaced.<br>(5) For water types without gauges, their fullness shall be determined by "hefting."<br>(6) Any obvious physical damage, corrosion, leakage, or clogged nozzles shall be noted.<br>(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.**<br><br>**Verify the fire detectors initiate the appropriate protection function and alarms.**<br><br>**This test should include verification that the unit differential relay would initiate $CO_2$ discharge.]** | **[Annually]** | FIST 5-12 Section 9.2<br>PEB 55 Appendix 16 |
| **[Perform visual inspection on all types of batteries located within fire detection and alarm systems.]**<br>(1) Lead-acid batteries will be examined for signs of failure such as bulging, cracking, open vents, leaking electrolyte, and corrosion.<br>(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; $CO_2$.<br><br>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.<br><br>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.]** | Unmonitored: **[Plant Rounds]**<br><br>Monitored: **[Annually]** | |
| **[When the unit is offline, ensure heaters within air housing are functioning properly.]**<br>Ensure air housing temperature is higher than ambient temperature of the facility. | Unmonitored: **[Plant Rounds]**<br><br>Monitored: **[Monthly]** | |
| **[Perform generator thrust-bearing insulation and oil film resistance test.]** | Unmonitored: **[3 Years]**<br><br>Monitored: **[6 Years]** | FIST 3-11<br>FIST 2-12 2.11.2 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| Perform partial discharge test if unit equipped with sensors. | Unmonitored: Annually<br><br>Monitored: No periodic maintenance required | PEB 29 |
| Perform Insulation Resistance (IR) and Polarization Index (PI) test to identify factors in assessing serviceability of generator or large motor armature winding insulation.[1] | Unmonitored: 6 years<br><br>Monitored[2]: No periodic maintenance required | PEB 29 Page 26<br>FIST 3-1 Sections 15-19 |
| Perform Insulation Resistance (IR) and Polarization Index (PI) test to identify factors in assessing serviceability of generator or large motor field winding insulation. | Unmonitored: 6 years<br><br>Monitored[3]: No periodic maintenance required | PEB 29 Page 26<br>FIST 3-1 Sections 15-19 |
| **[Perform field winding (rotor) pole drop test]** | Unmonitored: **[6 years]**<br><br>Monitored[4]: No periodic maintenance required | PEB 29 |
| **[Perform Armature (Stator) Winding DC-Ramp Test.]** | Periodic: **[6 Years]**<br><br>Non-Periodic: **[Before rotor removal and after rotor installation]**<br><br>**[After maintenance activity with** | FIST 3-1 Section 39<br>PEB 29 |

| | | |
|---|---|---|
| | **potential to damage the windings (e.g. re-wedging, major repairs, moving of stator to re-center alignment, etc.]**<br><br>**[After any major through fault or misoperation that exposes windings to: a.) stator current equal to, or greater than, 2.5 per-unit, or b.) if through fault current is unknown.]**<br><br>**[After misoperation having the potential to overheat stator windings.]** | |

[1]DC Ramp testing may be performed in-lieu of IR and/or PI testing generator and large motor armature (stator) windings.

[2]Stator injection resistance to ground monitor

[3]Rotor injection resistance to ground monitor

[4]Airgap flux probe monitor

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# 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<br>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<br>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<br>RSHS Section 8.5 |
| **[Perform personal protective ground cable millivolt drop test.]** | **[Annually]** | PEB 29 Page 37<br>FIST 5-1 Section 10.3<br>FIST 5-1 Section 10.4<br>PEB 55 Appendix 22 |
| **[Functionally check electrical and electronic indicating type detectors.]** | **[Before each use and Annually]** | FIST 5-1 Section 6.5<br>PEB 55 Appendix 22 |
| **[Hotsticks and live-line tools shall be electrically tested in a shop or laboratory.]** | **[Annually]** | FIST 3-29 Appendix A<br>FIST 5-1 Section 10.3<br>FIST 5-1 Section 10.4<br>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 the clothing manufacturer. Cleaning of** | **{Before each use}** | FIST 5-14 Section 9.3 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| 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<br>PEB 55 Appendix 23 |
| **[Perform DC High Pot Test]** | **[5 years]** | FIST 3-1 Section 46<br>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}***<br><br>**[Upon commissioning and after setting changes or repairs.]**<br><br>Sudden Pressure or Buchholz Relays see section 34.4 | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 12<br>PSMP<br>PRCB 11-6 |
| **{Verify relay settings are as specified.}**<br><br>Verify relay settings match official settings as documented in the Reclamation Relay Database. | **[2 years] {N}*** | PSMP<br>PRCB 11-6 |

**Harsh conditions: Defined as excessive vibration, dusty atmospheres, and extreme temperature changes.

**{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.]** | **[Plant Rounds]** | PEB 55 Appendix 24 |
| **{Perform solid-state relays calibration and functional testing.}** | **[2 years] {N}*** <br><br> Non-periodic: <br><br> **[Upon commissioning and after setting changes or repairs]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 13.1<br>PRCB 11-6 |
| **{Verify the settings are as specified}** <br><br> Verify relay settings match official settings as documented in the Reclamation Relay Database. | **[2 years] {N}*** | PSMP<br>PRCB 11-6 |

**{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[1]

If monitoring is used to extend maintenance intervals, the following definitions apply:

A Microprocessor protective relay is a relay where the voltage and/or current wave form sampling three or more times per down cycle and conversion of samples to numeric values for measurement calculations by microprocessor electronics.

An Internally monitored relay includes a microprocessor protective relay with internal self-diagnostics and alarming and alarming for power supply failure. It also requires that following a relay trip event, correct operation of relay and associated protections system is validated. This includes reviewing relay trip event reports and protection system operation logs to confirm that valid instrument transformer signals were received and recorded by relay, lockout relay operated as expected, annunciation and alarms were correct, relay inputs and outputs operated as expected, and applicable relay settings are correct.

An Externally monitored relay includes all internal monitored attributes plus AC measurements continuously verified by comparison to an independent AC measurement source with alarming for excessive error, some or all binary or status inputs and control outputs are monitored by a process that continuously demonstrates ability to perform as designed, with alarming for failure, and alarming for change of settings.

| Maintenance Task | Frequency[2,3] | Reference |
|---|---|---|
| **[Perform visual inspection on microprocessor-based relays to check for relay trouble indication.]** | Unmonitored relay:<br>**[Plant Rounds]**<br><br>Internally and externally monitored relays-<br>No periodic maintenance required | PEB 55 Appendix 25 |

| Maintenance Task | Frequency[2,3] | Reference |
|---|---|---|
| **{Perform verification of binary inputs and outputs that are essential to proper functioning of the protection system.}** | Unmonitored relay:<br>**[5 years] {N}***<br><br>Internally monitored relay:<br>**[10 years] {N}***<br><br>Externally monitored relay with Unmonitored inputs and outputs:<br>**[10 years] {N}***<br><br>Externally monitored relay with monitored inputs and outputs:<br>No periodic maintenance required<br>**[Upon commissioning]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 14.2<br>PEB 52<br>PRCB 11-6 |
| **[Perform microprocessor relay functional testing]** | Unmonitored relay<br>or<br>any relay greater than 20 years old**:<br>**[5 Years]**<br><br>Internally and externally monitored relays less than or equal to 20 years old**:<br>**[10 years]**<br><br>**[Upon commissioning, 1 year after commissioning and after setting changes[4,5], repairs, or firmware[5] updates]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 14<br>PSMP |

| Maintenance Task | Frequency[2,3] | Reference |
| --- | --- | --- |
| **{Perform microprocessor relay setting verification and documentation.}**<br><br>Verify relay settings match official settings as documented in the Reclamation Relay Database. | Unmonitored relays:<br>**[5 years] {N}***<br><br>Internally monitored relays:<br>**[10 years] {N}***<br><br>Externally monitored relays:<br>No periodic maintenance required<br><br>Non-periodic:<br>**[Upon commissioning and after setting changes, repairs, or firmware updates]**<br>Following a relay operation | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 14.10<br>FIST 6-4 Appendix A.3<br>PRCB 11-6 |

[1] – **{Microprocessor protective relay is a relay where the voltage and/or current wave form sampling three or more times per down cycle and conversion of samples to numeric values for measurement calculations by microprocessor electronics.} {N}*.**

[2] – Internally monitored relay includes **{a microprocessor protective relay with internal self-diagnostics and alarming and alarming for power supply failure.} {N}*.**

It also requires that **[following a relay trip event, correct operation of relay and associated protections system is validated. This includes reviewing relay trip event reports and protection system operation logs to confirm that valid instrument transformer signal were received and recorded by relay, lockout relay operated as expected, annunciation and alarms were correct, relay inputs and outputs operated as expected, and applicable relay settings are correct.]**

[3] – Externally monitored relay includes **{all internal monitored attributes plus AC measurements continuously verified by comparison to an independent AC measurement source with alarming for excessive error, some or all binary or status inputs and control outputs are monitored by a process that continuously demonstrates ability to perform as designed, with alarming for failure, and alarming for change of settings.} {N}*.**

[4] – Functional testing of microprocessor-based relay with setting changes can be limited to a function check of the affected element if the change is limited in scope, such as a change of a variables(s), a pickup value, a time value, or a curve type.

[5] – If identical setting changes and/or identical firmware upgrades are being performed on identical relays (same part and version numbers) then function testing needs only to be performed on the initial relay to be updated and not required on subsequent identical relays. If temporary setting changes were made (E.g. for testing purposes) and then original setting are restored, functional testing is not required.

****** – 10-year interval valid for relays that do not exceed their predicted life expectancy, which is defined as 20 years from manufacture date year. For relays that exceed their predicted life expectancy, testing interval is reduced to 5 years.

**{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]** | Unmonitored lockout relays and circuit breaker coils:<br>**[Plant Rounds]**<br><br>Monitored[1] lockout relays and circuit breaker coils:<br>No periodic maintenance is required | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Sections 8, 9.4<br>PEB 51 Table 1 |
| **{Perform functional testing of lockout relays by verifying electrical operation of electromechanical lockout devices}** | **[5 years] {N}*** | FIST 3-8 Section 8<br>FIST 3-8 Section 9.2<br>PSMP<br>PRCB 11-6 |
| **[Perform sealed lockout relay timing tests]** | Unmonitored:<br>**[5 years]**<br><br>Monitored[2]:<br>No periodic maintenance required | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 9.2<br>PEB 51 |
| **[Perform non-sealed lockout relay timing tests, cleaning, and lubrication.]**<br><br>Note: Lockouts may not need to be oiled or cleaned; see manufacturer's instructions. | Unmonitored:<br>**[5 years]**<br><br>Monitored[2]:<br>No periodic maintenance required | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 9.2 |

[1] Monitored lockout relay and circuit breaker trip coil for continuity includes real-time lockout and breaker trip coil continuity monitor and alarm.

[2] Monitored lockout relay and circuit breaker trip coil for timing includes real-time monitoring of lockout relay trip timing, breaker trip timing, and alarming if trip times are excessive.

**{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}**<br><br>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.<br><br>Note: 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. | Unmonitored:<br>**[5 Years] {N}***<br><br>Monitored[1]:<br>No periodic maintenance required<br><br>Non-periodic:<br>**[Upon installation, after any wiring changes and after any misoperation] {N}*** | FIST 3-8 Section 8<br>FIST 3-8 Section 9.2, 9.3<br>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.

[1] Monitored protection circuit functional testing includes a self-test and notification feature of items outlined under the maintenance task.

## 26.7 Maintenance Schedule for Communication Systems for Protective Relaying

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Verify protection system communications systems necessary for the correct operation of protective functions are functional}** | Unmonitored communication system: **[Quarterly]** **{N}*** <br><br> Channel monitoring communication system[1]: No periodic maintenance required <br><br> Performance monitoring communication system[2]: No periodic maintenance required <br><br> **[Upon commissioning, and after wiring modifications]** | FIST 3-8 Section 14.9<br>PEB 51 Table 1<br>PSMP<br>PRCB 11-6 |
| **{Verify protection system communications system necessary for correct operation of protection systems meets performance criteria pertinent to the communication technology applied (e.g. signal level, reflected power, or data error rates.)}** | Unmonitored communication system: **[5 Years]** **{N}*** <br><br> Channel monitoring communication system[1]: **[10 Years]** **{N}*** <br><br> Performance monitoring communication system[2]: No periodic maintenance required <br><br> **[Upon commissioning and after wiring modifications]** | FIST 3-8 Section 14.9<br>PEB 51 Table 1<br>PSMP<br>PRCB 11-6 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **{Verify operation of communication system input and outputs that are essential to the proper function of the protection system}** | Unmonitored communication system:<br>**[5 Years] {N}***<br><br>Channel monitoring communication system[1]:<br>**[10 Years] {N}***<br><br>Performance monitoring communication system[2] unmonitored inputs and outputs:<br>**[10 Years] {N}***<br><br>Performance monitoring communication system[2] monitored inputs and outputs:<br>No periodic maintenance required<br><br>**[Upon commissioning and after wiring modifications]** | PSMP<br>PRCB 11-6 |

[1] Channel Monitoring Communication System is any communication system with continuous monitoring or periodic automated testing for the presence of the channel function and alarming or loss of function.

[2] Performance Monitoring Communication System is any communication system with continuous monitoring or periodic automated testing for the performance of the channel using criteria pertinent to the communication technology applied (e.g. signal level, reflected power or data error rate) and alarming for excessive performance degradation and some or all binary or status inputs and control outputs are monitored by a process that continuously demonstrates ability to perform as designed with alarming for failure.

**{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.**<br><br>**Test the overall performance of the communication schemes, including logic, signal quality, and overall performance to validate the SCADA performance.]** | **[Upon commissioning,**<br><br>**Quarterly,**<br><br>**and after wiring modifications]** | PEB 55 Appendix 26 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Test monitored analog SCADA communication equipment.<br><br>Test the overall performance of the communication schemes, including logic, signal quality, and overall performance to validate the SCADA performance.]** | **[Upon commissioning,<br><br>every 5 years,<br><br>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<br>PEB 55 Appendix 26 |
| **[Check the enclosure to ensure it is in good overall condition.<br><br>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<br>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.]**<br><br>Inspect the alarm panel for damage (electrical or physical), loose connections, or foreign debris such as dirt, dust, and metal shavings.<br><br>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).<br><br>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.<br><br>Repair or replace as necessary.<br><br>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.]**<br><br>Ask alarm monitor to verify panel is on-line using the ESS software at the alarm monitor client workstation.<br><br>The alarm panel will be either off-line or on-line. | **[Annually]** | PEB 59 Table 1 |
| **[Perform card reader preventative maintenance.]**<br><br>Inspect card reader.<br><br>Inspect the card reader for damage (electrical or physical) and loose connections.<br><br>Inspect LED lights and light bars to verify proper operation.<br><br>Repair or replace as necessary.<br><br>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.]**<br><br>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).]**<br><br>Inspect BMS.<br><br>There should be no metal filings or other debris on the sensor.<br><br>Wire insulation should be free of damage and in good condition (free of nicks, exposed copper, etc.).<br><br>Armored cable should be free of nicks, gaps, and burrs which could damage the wiring, device, or personnel.<br><br>Repair or replace as necessary.<br><br>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).]**<br><br>Use a key to open the door. The alarm monitor should receive a door forced open alarm.<br><br>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.<br><br>Close the door; the door held alarm should clear. Select and acknowledge the door forced open alarm. The alarm should clear.<br><br>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).<br><br>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.]**<br><br>Inspect magnetic lock.<br><br>Verify proper alignment of metal plate attached to door and electro-magnetic assembly on frame. See manufacturer's documentation for proper alignment procedure.<br><br>There should be no metal filings or other debris on metal parts.<br><br>Repair or replace as necessary.<br><br>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.]**<br><br>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.<br><br>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.<br><br>The magnetic lock should release and the door should open normally.<br><br>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.<br><br>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.<br><br>Push on door again and verify it remains secure. | **[Annually]** | PEB 59 Table 1 |
| **[Perform preventative maintenance on electronic locks/strikes.]**<br><br>Inspect electronic lock/strike for missing hardware.<br><br>Repair or replace as necessary.<br><br>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]**<br><br>With the door in the secure position (closed), try to open the door. The door must remain closed and not activate the door contact.<br><br>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.<br><br>The electronic strike or latch should release and the door should open normally.<br><br>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.<br><br>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.<br><br>Push on door again and verify it remains secure. | **[Annually]** | PEB 59 Table 1 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform preventative maintenance on motion detectors.]**<br><br>Inspect motion detector.<br><br>Inspect for missing hardware.<br><br>Inspect for damage (e.g. cracked housing, proper mounting, etc.).<br><br>Repair or replace as necessary. If motion detector is damaged, order new motion detector and replace as soon as possible.<br><br>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.]**<br><br>Have personnel stand outside the detection area and walk slowly towards the motion detector.<br><br>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.]**<br><br>Inspect tamper switch.<br><br>Inspect plunger for mechanical actuation (plunger moves freely in and out).<br><br>Inspect for loose wiring and exposed cooper.<br><br>Repair or replace as necessary.<br><br>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.]**<br><br>Open the device, the alarm monitor should receive a tamper alarm.<br><br>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.]**<br><br>Inspect enclosure.<br><br>Inspect exterior of enclosure for damage.<br><br>Minor scratches and dents are to be expected. Enclosures located in temperature controlled areas which have minor paint damage are acceptable.<br><br>Major paint damage (larger than 1") or paint damage on devices in uncontrolled climate areas must be repaired.<br><br>Inspect utilized knockout holes to ensure conduit/enclosure connecters are tight and cables are not being damaged during transition.<br><br>Inspect knockout holes not being utilized to ensure they have original plugs or are plugged using appropriate equipment/ knock out blanks.<br><br>Repair or replace as necessary.<br><br>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).]**<br><br>Inspect dome camera.<br><br>Inspect cables, connectors, and cable shielding between enclosure, pole and camera for abrasions, cracks, or deterioration.<br><br>Inspect for damage on the camera housing, including insect damage, lightning damage, and/or other mechanical failure.<br><br>Repair or replace as necessary.<br><br>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).]**<br><br>**Fixed Camera Functional Test**<br>Verify that user is able to zoom in/out. (Not applicable on all fixed cameras.)<br><br>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.<br><br>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.)<br><br>**PTZ and Thermal Camera Functional Test**<br>Verify that video image is clear and presentable.<br><br>Verify that user is able to pan the camera left and right, tilt the camera up and down, and zoom in/out.<br><br>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.)<br><br>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).]**<br><br>Inspect box camera.<br><br>Inspect cables, connectors, and cable shielding between enclosure, pole and camera for abrasions, cracks, or deterioration.<br><br>Inspect for damage on the camera housing, including insect damage, lightning damage, and or other mechanical failure.<br><br>Repair or replace as necessary.<br><br>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).]**<br><br>**Fixed Camera Functional Test**<br>Verify that user is able to zoom in/out. (Not applicable on all fixed cameras.)<br><br>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.<br><br>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.)<br><br>**PTZ and Thermal Camera Functional Test**<br>Verify that video image is clear and presentable.<br><br>Verify that user is able to pan the camera left and right, tilt the camera up and down, and zoom in/out.<br><br>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.)<br><br>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).]**<br><br>Inspect sealed cameras.<br><br>Inspect cables, connectors, and cable shielding between enclosure, pole and camera for abrasions, cracks, or deterioration.<br><br>Inspect for damage on the camera housing, including insect damage, lightning damage, and or other mechanical failure.<br><br>Repair or replace as necessary.<br><br>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).]**<br><br>**Fixed Camera Functional Test**<br>Verify that user is able to zoom in/out. (Not applicable on all fixed cameras.)<br><br>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.<br><br>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.)<br><br>**PTZ and Thermal Camera Functional Test**<br>Verify that video image is clear and presentable.<br><br>Verify that user is able to pan the camera left and right, tilt the camera up and down, and zoom in/out.<br><br>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.)<br><br>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.]**<br><br>Inspect pole.<br><br>Wood pole: check for cracking, damage and rot.<br><br>Metal pole: check for cracking, damage, metal fatigue, mechanical damage, and corrosion.<br><br>Concrete pole: check for cracking, damage, and exposed rebar.<br><br>Repair or replace as necessary. | **[Annually]** | PEB 59 Table 1 |
| **[Perform preventative maintenance on radars.]**<br><br>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.<br><br>Take care when working on the radar.<br><br>Inspect casing for damage. Paint damage on casing must be repaired.<br><br>Inspect front of radar for rips or holes.<br><br>Inspect wiring and ensure connector is secure.<br><br>Inspect mount and cable. Verify mounting hardware is tight and free of corrosion.<br><br>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.]**<br><br>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.<br><br>Once subject is clear of restricted/exclusion area, the alarm should clear. Select and acknowledge the alarm. The alarm should clear.<br><br>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).]**<br><br>Inspect DVR/NVR.<br><br>Inspect connectors for damage and exposed copper.<br><br>Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring).<br><br>Inspect wiring for damage.<br><br>Verify optical disk drive tray opens/closes properly.<br><br>Repair as or replace necessary.<br><br>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).]**<br><br>Verify display of video using the DVR/NVR as the video source.<br><br>Verify configuration settings (e.g. record on motion, schedule, record 24/7, etc.) are properly set according to local configuration requirements.<br><br>Verify that time stamp is consistent between all cameras and the ESS system (if applicable) and that the time stamp is accurate.<br><br>Verify that video is recording according to configuration settings referenced above.<br><br>Select a 5 minute segment of recorded video from the DVR/NVR and export using the following removable media: CD or DVD, USB<br><br>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.).]**<br><br>Inspect network device (e.g. switches, encoder, decoder, etc.).<br><br>Inspect connectors for damage and exposed copper.<br><br>Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring).<br><br>Inspect wiring for damage.<br><br>Listen for any excessive vibrations or noise from the fan or power supply.<br><br>Repair or replace as necessary.<br><br>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.).]**<br><br>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.]**<br><br>Inspect computers (e.g. workstations and servers) and peripherals.<br><br>Inspect connectors for damage and exposed copper.<br><br>Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring).<br><br>Inspect wiring for damage.<br><br>Listen for any excessive vibrations or noise from the fan or power supply.<br><br>Repair or replace as necessary.<br><br>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.]**<br><br>Inspect the interior of the computer.<br><br>Inspect connectors for damage and exposed copper.<br><br>Inspect wire connection points to ensure they are tight and not stressed (e.g. other equipment and or cabling is not weighting down wiring).<br><br>Inspect wiring for damage.<br><br>Listen for any excessive vibrations or noise from the power supply or system fans.<br><br>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.<br><br>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.]**<br><br>Inspect battery.<br><br>Check battery for warping, cracking, or bulging.<br><br>Check battery terminals for corrosion.<br><br>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.<br><br>Clean exterior using a dry cloth to remove dust, dirt or debris. | **[Annually]** | PEB 59 Table 1 |
| **[Perform functional test on battery/battery system.]**<br><br>Operational status verified through daily use. | **[Annually]** | PEB 59 Table 1 |
| **[Perform preventative maintenance on power supply/board.]**<br><br>Inspect power supply/board, such as Altronix PD8, Altronix power supplies, 24VAC camera power supplies, etc.<br><br>Check for cracking of components and wiring.<br><br>Check for scorch marks and loose wiring on components and at terminal connections.<br><br>Repair or replace as necessary.<br><br>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.]**<br><br>Operational status verified through daily use. | **[Annually]** | PEB 59 Table 1 |

| | | |
|---|---|---|
| **[Perform preventative maintenance on vehicle barriers.]**<br><br>Inspect automated vehicle barrier (AVB) equipment:<br><br>Related safety devices (including induction safety loop detectors) and warning signs/signals/lights.<br><br>Check and adjust barrier operating speeds (where appropriate).<br><br>Covers and protective plates on equipment to prevent water or wildlife damage.<br><br>Hoses for damage, cracking, leaking and wear.<br><br>Safety signs, decals, and appropriate stickers and replace as necessary.<br><br>Hinge pins; lubricate when needed.<br><br>Relays, motor starters, and switches for signs of contact wear.<br><br>Indicator lights and traffic lights for proper operation; replace bulbs as necessary.<br><br>Areas that need touch-up paint or corrosion protection.<br><br>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.)<br><br>Repair or replace as necessary.<br><br>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.<br><br>Remove debris from all sump areas and system cabinets; clean and flush drains.<br><br>For system specifics and hydraulic fluid capacities, refer to the manufacturers manual and recommendations. | | |
| **[Perform functional test on vehicle barriers.]**<br><br>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.]**<br><br>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.<br><br>The motion detector should detect motion within two steps of entry through the door threshold.<br><br>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.]**<br><br>Insulating members – Check the overall cleanliness; check for tracking; inspect for cracked or broken segments.<br><br>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.<br><br>Mechanical linkages and operating rods – Ensure linkages and operating rods have not been bent or distorted; ensure all fastenings (bolts, nuts, etc.) are secure.<br><br>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.<br><br>Interrupting device (if equipped) – Check condition of tank and levels.<br><br>Motor operator (if equipped) – Check condition of enclosure; check for moisture; | **[Semi-annually**<br><br>**Or after a short circuit event]** | PEB 46 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| check for proper operation of space heaters; check the overall cleanliness of enclosure.<br><br>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.]**<br><br>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 the grounding leads and connections of structures and apparatus]** Verify ground leads (Jumpers) are not loose, or broken. Check and tighten connectors and clamps in ground leads. | Periodic: **[Annually]**<br><br>Non-periodic: **[When grid is installed and after repairs.]** | PEB 55 Appendix 27 |
| **[Verify low impedance electrical connection of ground leads (jumpers) to a centrally located switchyard ground lead (e.g. a transformer ground)]** | Periodic: **[6 years]**<br><br>Non-periodic: **[When grid is installed and after repairs.]** | |
| **[Perform an impedance test (Fall-of-Potential test) of the ground grid and take step and touch voltage measurements in and nearby the ground grid]** | Periodic: **[12 Years]**<br><br>Non-periodic: **[When grid is installed and after repairs.]** | |

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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 |
| **[Verify power is available on all essential power, lighting, and control circuits.]** | **[Semi-annually]** | PEB 55 Appendix 28 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[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.**<br><br>**From the ground up, check transmission wood poles for signs of decay, misalignment, and damage from lightning or other causes.**<br><br>**Check cross arms for splitting.**] | **[Semi-annually]** | PEB 55 Appendix 28 |
| **[Perform steel structure from-the-ground check.**<br><br>**Check the structures for signs of rusting or loose or damaged members.**<br><br>**Check condition of footings and anchors particularly in locations subject to soil erosion, movement, or settling.**<br><br>**Treat corrosion with inhibitor.**<br><br>**Check for loose or broken pole down leads, or broken or corroded ground connections.**<br><br>**Tighten clamps on ground connections.**<br><br>**Inspect counterpoise conductors at intervals for corrosion and poor connections. This is particularly important in corrosive soil.**<br><br>**Check resistance of ground connection.]** | **[Semi-annually]** | PEB 55 Appendix 28 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform from-the-ground inspection of main conductors and overhead ground wires with field glasses to detect broken strands, incorrect sag, and clearances, etc.**<br><br>**Inspect splices with field glasses to detect failure.**<br><br>**Make from-the-ground inspection of hardware to detect loose bolts, pins, etc.**<br><br>**Make from-the-ground inspection of condition of insulators to detect broken skirts and excessive dirt.]** | **[Semi-annually]** | PEB 55 Appendix 28 |
| **[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.**<br><br>**Check fence ground connections.**<br><br>**Cut weeds and grass as necessary, and apply weed killers where found to be effective.**<br><br>**Repair eroded soil banks, retaining walls, roads, and walks.**<br><br>**Remove rubbish.**<br><br>**Check danger signs on fence and gates.]** | **[Annually]** | PEB 55 Appendix 28 |
| **[Perform transmission line maintenance.**<br><br>**Patrol transmission line rights-of-way.]** | **[Annually]** | PEB 55 Appendix 28 |

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# 32.0 RESERVED

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# 33.0 Elevators

## 33.1 General

An elevator is a hoisting mechanism which moves a car within guides to two or more landings. There are many different types of elevators which fall into two main categories: electric and hydraulic.

Any adjustments to the elevator shall be completed by a qualified individual. Category 1 and 5 Testing shall be completed by a Qualified Elevator Inspector.

The following maintenance tables are in reference to the tasks outlined in FIST 2-10, *Maintenance, Inspection, and Testing of Electric and Hydraulic Elevators*.

## 33.2 Maintenance Schedule for Electric Elevators

| Maintenance Task | Frequency | Reference |
|---|---|---|
| Visual Inspection | **[Monthly]** | FIST 2-10, Section 4.2.1.1 |
| Operational Inspection | **[Monthly]** | FIST 2-10 , Section 4.2.1.2 |
| General Housekeeping | **[Monthly]** | FIST 2-10, Section 4.2.1.3 |
| Machine Brake | **[Quarterly]** | FIST 2-10, Section 4.2.1.4 |
| Governor | **[Quarterly]** | FIST 2-10, Section 4.2.1.5 |
| Car Doors | **[Quarterly]** | FIST 2-10, Section 4.2.1.6 |
| Controller and Selector | **[Quarterly]** | FIST 2-10, Section 4.2.1.7 |
| Car Telephone | **[Quarterly]** | FIST 2-10, Section 4.2.1.8 |
| Buffers | **[Quarterly]** | FIST 2-10, Section 4.2.1.9 |
| Motor Brushes and Commutators | **[Quarterly]** | FIST 2-10, Section 4.2.1.10 |
| Car Ventilation System and Heater | **[Quarterly]** | FIST 2-10, Section 4.2.1.11 |
| Car Top and Hoistway | **[Quarterly]** | FIST 2-10, Section 4.2.1.12 |
| Traveling Cables | **[Quarterly]** | FIST 2-10, Section 4.2.1.13 |
| Wire Ropes and Fastenings | **[Quarterly]** | FIST 2-10, Section 4.2.1.14 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| Sheaves | **[Quarterly]** | FIST 2-10, Section 4.2.1.15 |
| Safeties | **[Quarterly]** | FIST 2-10, Section 4.2.1.16 |
| Comprehensive Inspection | **[Semi-Annual]** | FIST 2-10, Section 4.3.1 |
| Category 1 Testing | **[Annual]** | FIST 2-10, Section 4.4.1.1 |
| Category 5 Testing | **[5 years]** | FIST 2-10, Section 4.4.1.2 |

## 33.3 Maintenance Schedule for Hydraulic Elevators

| Maintenance Task | Frequency | Reference |
|---|---|---|
| Visual Inspection | **[Monthly]** | FIST 2-10, Section 4.2.2.1 |
| Operational Inspection | **[Monthly]** | FIST 2-10 , Section 4.2.2.2 |
| General Housekeeping | **[Monthly]** | FIST 2-10, Section 4.2.2.3 |
| Plunger Seals | **[Quarterly]** | FIST 2-10, Section 4.2.2.4 |
| Governor | **[Quarterly]** | FIST 2-10, Section 4.2.2.5 |
| Car Doors | **[Quarterly]** | FIST 2-10, Section 4.2.2.6 |
| Car Telephone | **[Quarterly]** | FIST 2-10, Section 4.2.2.7 |
| Buffers | **[Quarterly]** | FIST 2-10, Section 4.2.2.8 |
| Plunger and Cylinder | **[Quarterly]** | FIST 2-10, Section 4.2.2.9 |
| Test Mechanism | **[Quarterly]** | FIST 2-10, Section 4.2.2.10 |
| Car Ventilation System and Heater | **[Quarterly]** | FIST 2-10, Section 4.2.2.11 |
| Car Top and Hoistway | **[Quarterly]** | FIST 2-10, Section 4.2.2.12 |
| Traveling Cables | **[Quarterly]** | FIST 2-10, Section 4.2.2.13 |
| Wire Ropes and Fastenings (if equipped) | **[Quarterly]** | FIST 2-10, Section 4.2.2.14 |
| Sheaves | **[Quarterly]** | FIST 2-10, Section 4.2.2.15 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| Comprehensive Inspection | **[Semi-Annual]** | FIST 2-10, Section 4.3.2 |
| Category 1 Testing | **[Annual]** | FIST 2-10, Section 4.4.2.1 |
| Category 3 Testing | **[3 years]** | FIST 2-10, Section 4.4.2.2 |
| Category 5 Testing | **[5 years]** | FIST 2-10, Section 4.4.2.3 |

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# 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 |
|---|---|---|
| **[High-Voltage Instrument Transformers: Visually inspect oil insulated 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. Perform Visual Inspection of bushings for visible cracks, contamination, and oil level]** | **[Annually]** | Manufacturers Instruction |
| Infrared scan and thermal analysis of 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, and insulation resistance.]** | **[Annually for U type]**<br><br>**[6 years]** | FIST 3-30 Sections 4.1.8, 4.7, Table 17 |
| **[For PT's, perform in-depth bushing inspection for any carbon tracking, leaks, and cracks]** | **[6 years]** | FIST 3-30 Section 4.1.8 |
| **[For PT's clean bushing and repair chipped spots]** | **[6 years]** | FIST 3-31 |
| **[Perform current transformer excitation test.]** | **[10 years]**<br><br>**[Upon Commissioning]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 6 |
| **[Perform insulation resistance tests.]** | **[10 years]**<br><br>**[Upon commissioning, and after major[1] wiring modifications]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 5.3<br>PEB 51 Table 1 |
| **[Verify CT and PT secondary circuits are grounded at only one point, and secondary grounding must be checked and verified.]** | **[10 years]**<br><br>**[Upon commissioning, and after major[1] wiring modifications]** | FIST 3-8 Section 3 Table 1<br>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.}** | Unmonitored and internally monitored relays:<br>**[10 years]** **{N}***<br><br>Externally Monitored relays without independent[2] instrument transformers:<br>**[10 years]** **{N}***<br><br>Externally Monitored relays with independent[2] instrument transformers: No periodic maintenance required<br><br>**[Upon commissioning and after wiring modifications]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 5.2<br>PEB 51 Table 1<br>PSMP |
| **[Measure instrument transformer burdens.]** | No periodic maintenance required<br><br>**[Upon commissioning and after major[1] wiring modifications]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 5.1<br>PEB 51 |
| **[Offline test instrument transformer secondary circuit magnitude (ratio and phase) polarity, phasing, and secondary circuit connections.]** | No periodic maintenance required<br><br>**[Upon commissioning of new/replacement instrument transformer and after major[1] wiring modifications.]** | FIST 3-8 Section 3 Table 1<br>FIST 3-8 Section 5.4<br>PEB 51 |

| Maintenance Task | Frequency | Reference |
|---|---|---|

[1] Major wiring modifications would include replacing multi-conductor plant cables, replacing multiple relays, moving location of multiple relays, etc. A minor wiring modification is limited in scope and all wiring changes can be visually verified and physically traced.

[2] Externally monitored relays defined in section 26.4 Maintenance Schedule for Microprocessor Relays. Independent instrument transformers are defined as 2 or more instrument transformer whose output signals can be compared to detect for excessive error. Examples include comparison of 2 instrument transformers on the same phase and bus, comparison of same phase differential current transformers, comparison of 3-phase current transformers on a delta connected bus, or comparison of instrument transformers on either side of a power transformer.

**{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 |
|---|---|---|
| Infrared scan and thermal analysis of transformer | Annually | FIST 3-30 Section 3.0<br>FIST 3-30 Section 3.1.1 PEB 55 Appendix 29 |
| Infrared scan and thermal analysis of the bushings and all wirings | Annually | FIST 3-30 Sections 3.2.5, 4.1.8 |
| **[Check the temperature rise (above ambient) if near or above nameplate rating, check for overloading.** | **[Annually]** | FIST 3-30 Section 3.0<br>FIST 3-30 Section 3.1.1 PEB 55 Appendix 29 |
| **[If equipped, check the temperature alarm for proper operation.]** | **[Annually]** | FIST 3-30 Section 3.0<br>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<br>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<br>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<br>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<br>FIST 3-30 Section 3.1.1<br>PEB 55 Appendix 29 |
| **[Inspect windings for dirt- and heat-discolored insulation and structure problems.]** | **[6 Years]** | FIST 3-30 Section 3.0<br>FIST 3-30 Section 3.1.1 PEB 55 Appendix 29 |
| **[Check for loose connections.]** | **[6 Years]** | FIST 3-30 Section 3.0<br>FIST 3-30 Section 3.1.1 PEB 55 Appendix 29 |
| **[Check for carbon tracking and cracked, chipped, or loose insulators.]** | **[6 Years]** | FIST 3-30 Section 3.0<br>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.]** | **[6 Years]** | FIST 3-30 Section 3.0<br>FIST 3-30 Section 3.1.1 PEB 55 Appendix 29 |
| **[Perform Visual Inspection of bushings for visible cracks, contamination, and oil level.]** | **[6 Years]** | FIST 3-30 Section 4.1.8<br>FIST 3-2 Section IV B |
| **[Perform In-depth bushing Inspection for any carbon tracking, leaks, and cracks]** | **[6 Years]** | FIST 3-30 Section 4.1.8 |
| **[Clean bushings and repair chipped spots, remove and clean bushing interphase barriers.]** | **[6 Years]** | FIST 3-31 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Perform transformer testing including winding resistance, turns ratio, (dielectric power factor* or insultation resistance), excitation current, and hot collar testing on bushings.]** | **[When new before energizing]**<br><br>**[6 years]** | FIST 3-30 Section 4.7<br>PEB 29<br>PEB 55 Appendix 29 |

## 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 |
|---|---|---|
| **[Check the bushing oil level by viewing the oil-sight glass or the oil level gauge.]** | **[Weekly]** | FIST 3-30 Section 4.1.8<br>PEB 55 Appendix 30 |
| **[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]**<br><br>**[Annually]** | FIST 3-30 Section 4.1<br>PEB 55 Appendix 30 |
| **[Check transformer tank for excessive corrosion and oil leaks]** | **[After 1 month of service]**<br><br>**[Annually]** | FIST 3-30 Section 4.1<br>PEB 55 Appendix 30 |
| **[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]**<br><br>**[Annually]** | FIST 3-30 Section 4.1<br>PEB 55 Appendix 30 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Inspect water-oil heat exchangers.<br><br>Test and inspect the pumps.<br><br>Look for and repair leaks in piping and heat exchanger body.<br><br>Examine the latest DGA results for dissolved moisture and free water.]** | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Check the oil flow indicator.<br><br>Check correct alarm point activates when the pump stops.<br><br>Check that the pointer is in the right position when the pump is off and when it is running.]** | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Inspect and test the oil pumps.]** | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Inspect piping and connections for leaks.]** | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Override the temperature controller so that the pump starts.]** | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Check the oil pump motor current on all three phases with an accurate ammeter.]**<br>Record this information for later comparison, especially if there is no oil flow indicator. | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Carefully inspect all valves to make sure they are fully open. Listen for unusual noises.]** | **[After 1 month of service]<br><br>[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Inspect cooling system.**<br><br>**Inspect and test the fans.**<br><br>**Verify the temperature controller starts all the fans.]** | **[After 1 month of service]**<br><br>**[Annually]** | FIST 3-30 Section 3.2.6<br>PEB 55 Appendix 30 |
| **[Inspect pressure relief for leaks and indication for operation.]** | **[Annually]** | FIST 3-30, Section 4.1.5 |
| **[Perform DGA.]** | **[Annually]** | FIST 3-30 Section 3.1<br>FIST 3-30 Section 4.4<br>PEB 29<br>PEB 55 Appendix 31 |
| **[Perform Visual Inspection of bushings for visible cracks, contamination, and oil level.]** | **[Annually]** | FIST 3-30 Section 4.1.8<br>FIST 3-2 Section IV B |
| Infrared scan and thermal analysis of transformer | Annually | FIST 3-30 Section 3.1 |
| Infrared scan and thermal analysis of 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, and insulation resistance.]** | **[Annually for U type]**<br><br>**[6 years]** | FIST 3-30 Sections 4.1.8, 4.7, Table 17<br>PEB 1 |
| **{Test transformer fault pressure relaying by verifying the pressure or flow sensing mechanism is operable.}**<br><br>Includes sudden pressure devices and/or Buchholz relay. Testing system should include protection system circuit functional testing, including lockout relay testing. | **[5 Years] {N}*** | FIST 3-30 Section 4.1.6<br>PEB 55 Appendix 30<br>FIST 3-8 Section 8 |
| **[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 |

| Maintenance Task | Frequency | Reference |
|---|---|---|
| **[Test transformer gauges.]** | **[6 Years]** | FIST 3-30 Section 3.1 |
| **[Check the pressure gauge]** | **[6 Years]** | FIST 3-30 Section 4.2 |
| **[Inspect the gas pressure control components.]** | **[6 Years]** | FIST 3-30 Section 4.2.2 |
| **[Check conservator, inspect flange and look inside with a flashlight.]** | **[6 Years]** | FIST 3-30 Section 4.2<br>PEB 55 Appendix 30 |
| **[Test Thermometers and annunciation.<br><br>Functionally test the annunciator points, activate pumps/fans etc.]** | **[6 Years]** | FIST 3-30 Section 4.1.3<br>PEB 55 Appendix 30 |
| **[Check the tank oil level indicators and alarm/tripping circuits.<br><br>Verify annunciator points and relays respond correctly.]** | **[6 Years]** | FIST 3-30 Section 4.1.4<br>PEB 55 Appendix 30 |
| **[Check the pressure relief device for leaks at the gaskets.]** | **[6 Years]** | FIST 3-30 Section 4.1.5<br>PEB 55 Appendix 30 |
| **[Perform dielectric power factor and excitation current testing of transformer windings.]**[1] | **[When new before energizing and every 6 years]** | FIST 3-30 Section 4.7<br>PEB 29<br>PEB 55 Appendix 30 |

[1] – Refer to FIST 3-30, Section 4.7 for additional optional tests that are specific to each transformer.

**{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:**<br><br>**• Detecting and initiating devices de-energizes the transformer.**<br><br>**• Detecting and initiating devices trigger a fire water release.**<br><br>**• All components of the control circuitry operate correctly.**<br><br>**• Motors, pumps, solenoids, and valves operate correctly.**<br><br>**• Water is delivered to the discharge nozzles.**<br><br>**• Nozzles are free of debris.**<br><br>**• Containment system drain valves operate correctly.**<br><br>**• Sump pumps are deactivated.**<br><br>**• All alarms and indication function properly.]** | **[Annually]** | FIST 3-32 Section 10<br>PEB 55 Appendix 31 |

# 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]** | |
| **[Calibrate IR camera.]** | **[Annually]** | |
| **[Calibrate test equipment that is used to check the calibration or proper operation of other equipment.]** | **[Annually]** | |