DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street, NW
Washington, DC 20314-1000

*EP 1130-2-510

CECW-CO

Pamphlet
No. 1130-2-510

31 July 2022

Project Operations
HYDROPOWER OPERATIONS AND MAINTENANCE GUIDANCE AND PROCEDURES

1. Purpose. This pamphlet establishes the guidance for: hydropower generation data collection and reporting, hydropower operations, maintenance of and investment in U.S. Army Corps of Engineers (USACE) hydropower facilities, Power Review of Operations and Maintenance (PRO&M), and the hydropower craft training program. The guidance outlined in subsequent chapters of this pamphlet represents the best practices and recommended approaches to encourage simplicity and consistency in implementing the policy codified in Engineer Regulation (ER) 1130-2-510.

2. Applicability. This regulation applies to all USACE commands having responsibility for federal hydropower facilities.

3. Distribution Statement. Approved for public release; distribution is unlimited.

FOR THE COMMANDER:

4 Appendixes

JAMES J. HANDURA
COL, EN
Chief of Staff

*This pamphlet supersedes EP 1130-2-510, dated 13 December 1996.

SUMMARY of CHANGE

EP 1130-2-510
United States Army Corps of Engineers (USACE)

HYDROELECTRIC POWER OPERATIONS AND MAINTENANCE POLICIES

This administrative revision, dated 24 June 2022—

- Updates the Acting Chief of Staff.
- Adds the supersession statement on footer of signature page.
- Adds Tables List after Appendixes in the Table of Contents.
- Revises formatting as specified by technical editors.
- Revised text as specified in ER 25-30-1. Spelled out terms, added abbreviations in parentheses following the fully defined term if used more than once in the publication.
- Revised text as specified in ER 25-30-1. Used abbreviations when term was previously fully defined in the publication.
- Revised text as specified in ER 25-30-1. Spelled out introductory phrases in parentheticals rather than using abbreviations.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street, NW
CECW-CO Washington, DC 20314-1000

EP 1130-2-510

Pamphlet
No. 1130-2-510

31 July 2022

Project Operations
HYDROPOWER OPERATIONS AND MAINTENANCE GUIDANCE AND PROCEDURES

TABLE OF CONTENTS

Appendixes

Table List

Chapter 1
Introduction

1-1. Purpose. This pamphlet establishes the guidance for hydropower generation data collection and reporting, hydropower operations, maintenance of and investment in U.S. Army Corps of Engineers (USACE) hydropower facilities, Power Review of Operations and Maintenance (PRO&M), and the hydropower craft training program. The guidance outlined in subsequent chapters of this pamphlet represents the best practices and recommended approaches to encourage simplicity and consistency in implementing the policy codified in ER 1130-2-510.

1-2. Applicability. This regulation applies to all USACE commands having federal hydropower facilities.

1-3. Distribution Statement. Approved for public release; distribution is unlimited.

1-4. References.

a. Public Law (PL) 93-275 (Federal Energy Administration Act of 1974), Sec. 13(b), 5(a), 5(b), 5. https://www.congress.gov/bill/93rd-congress/house-bill/11793/text?r=9&s=1

b. PL 95-91, Section 302, 95th Congress, (91 Stat. 565), Department of Energy Organization Act, 4 August 1977. https://www.govinfo.gov/content/pkg/STATUTE-91/pdf/STATUTE-91-Pg565.pdf

c. PL 102-486 (Energy Policy Act of 1992), Sec. 1015. https://www.govinfo.gov/content/pkg/STATUTE-106/pdf/STATUTE-106-Pg2776.pdf

d. PL 116-260, Water Resources Development Act of 2020, 27 December 2020. https://www.congress.gov/116/plaws/publ260/PLAW-116publ260.pdf

e. PL 534, Section 5, 78th Congress, (58 Stat. 889), Flood Control Act of 1944, 22 December 1944. https://www.usbr.gov/power/legislation/fldcntra.pdf

f. Executive Order 13327, Federal Real Property Asset Management. https://www.govinfo.gov/content/pkg/FR-2004-02-06/pdf/04-2773.pdf

g. Army Regulation 190-13, Army Physical Security Program. https://irp.fas.org/doddir/army/ar190-13.pdf

h. Engineer Regulation (ER) 10-1-53, Roles and Responsibilities, Hydroelectric Design Center. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_10-1-53.pdf

i. ER 385-1-31, The Control of Hazardous Energy.
https://www.publications.usace.army.mil/portals/76/publications/engineerregulations/er_385-1-31.pdf

j. ER 500-1-1, Natural Disaster Procedures.
https://www.publications.usace.army.mil/portals/76/publications/engineerregulations/er_500-1-1.pdf

k. ER 1110-2-1200, Engineering and Design – Plans and Specifications.
https://www.publications.usace.army.mil/portals/76/publications/engineerregulations/er_1110-2-1150.pdf

l. ER 1130-2-500, Partners and Support (Work Management Policies).
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1130-2-500.pdf?ver=2013-09-08-233436-167

m. ER 1130-2-510, Hydropower Operations and Maintenance Guidance and Procedures.
https://www.publications.usace.army.mil/portals/76/publications/engineerregulations/er_1130-2-510.pdf

n. ER 1130-2-551, Hydropower Operations and Maintenance Policy Bulk Power System Reliability Compliance Program.
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1130-2-551.pdf

o. ER 1130-2-554, USACE Condition Assessments.
https://www.publications.usace.army.mil/Portals/76/Users/182/86/2486/ER%201130-2-554.pdf?ver=-QW0hSNrmnHJLrWa98G_Eg%3d%3d

p. Engineer Pamphlet (EP) 1130-2-500, Partners and Support (Work Management Guidance and Procedures).
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1130-2-500.pdf?ver=2013-08-22-104517-637

q. EP 1130-2-551, Hydropower Operations and Maintenance Policy Implementation of Bulk Power System Reliability Compliance Program.
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1130-2-551.pdf

r. Engineer Manual (EM) 385-1-1, Safety and Health Requirements.
https://www.publications.usace.army.mil/portals/76/publications/engineermanuals/em_385-1-1.pdf

s. North American Electric Reliability Corporation (NERC) Regulation, COM-003-1.
https://www.nerc.com/pa/Stand/Project%20200702%20Operating%20Personnel%20Communications/COM-003-1_White_Paper_May%202012.pdf

1-5. Records Management (Recordkeeping) Requirements. The records management requirement for all record numbers, associated forms, and reports required by this regulation are addressed in the Army's Records Retention Schedule—Army (RRS–A). Detailed information for all related record numbers is located in Army Records Information Management System (ARIMS)/RRS–A at https://www.arims.army.mil. If any record numbers, forms, and reports are not current, addressed, and/or published correctly in ARIMS/RRS–A, see Department of the Army (DA) Pamphlet 25-403, Guide to Recordkeeping in the Army, for guidance. Access this pamphlet on the official USACE publications web page at http://www.publications.usace.army.mil/.

Chapter 2
Hydropower Data Collection and Reporting

2-1. Purpose. This chapter establishes the guidance and procedures for collecting and reporting USACE hydropower data and statistics to ensure that each project, District, major subordinate command (MSC), and Headquarters Hydropower Business Line Manager has access to information on the operations, maintenance, and performance of the hydropower facilities.

2-2. Guidance. The guidance in this chapter is intended to aid the enterprise in adhering to the associated policy for collecting data and submitting reports within the requested timeframe.

a. Performance Reporting. The data to be collected and reported includes, at a minimum, the following:

(1) Unit Status: The currently recognized database for unit status is Operations and Maintenance Business Information link (OMBIL). Unit status change times are recorded to the precision of one second.

(2) Generation Output: The currently recognized database for generation output (MWh) is OMBIL. Generation output is recorded by unit on a monthly basis.

(3) Operations and Maintenance (O&M) Costs: The currently recognized database for O&M costs is Corps of Engineers Financial Management System. O&M costs are recorded at the project level per existing financial guidance.

b. Metrics and Calculations. The data collection requirements outlined in ER 1130-2-510, Chapter 2 are used by Headquarters USACE (HQUSACE) to assess performance using the metrics and calculations in Table 2-1:

Table 2-1
Metrics and Calculations

Metric	Calculation
Unit availability: Percent of time a unit is available to be dispatched.	(number of hours available/unit hours)
Forced unit outage: Percent of time a unit is not available to be dispatched due to unplanned reasons.	(hours of forced outage/unit hours)
Forced unit outage frequency: The number of outages per unit in a time period.	(number of forced outages by unit/specified timeframe)
Quality cost: What is spent per unit on O&M to get an hour of availability	(O&M dollars/number of hours available)
Production cost: What we spend to produce a megawatt.	(O&M dollars by unit/MWh)

c. U.S. Energy Information Administration (EIA) Reporting. Each MSC must ensure that all necessary monthly data and information is collected to properly complete all applicable reports for the Department of Energy (DOE). At a minimum, the following reports should be submitted within the appropriate time frame:

(1) EIA-860: Annual Electric Generator Report. Collects data on the status of existing electric generating plants and associated equipment in the United States, and those scheduled for initial commercial operation within 10 years of the filing of this report. For instructions, frequently asked questions, the form for this report, and DOE contact information, reference: https://www.eia.gov/survey/.

(2) EIA-923: Power Plant Operations Report. Collects information from regulated and unregulated electric power plants in the United States. Data collected include electric power generation, energy source consumption, end of reporting period fossil fuel stocks, as well as the quality and cost of fossil fuel receipts. For instructions, the form for this report, and DOE contact information, reference: https://www.eia.gov/survey/.

d. Capacity Changes. The currently recognized database for inputting capacity changes is OMBIL.

Chapter 3
Hydropower Operations

3-1. Purpose. This chapter provides guidance for safe and reliable operations of USACE hydropower facilities per policy established in Chapter 3 of ER 1130-2-510.

3-2. Guidance. The guidance provided in this chapter is intended to aid the enterprise in adhering to the associated policy and operate USACE hydropower facilities in the most consistent and cost-effective manner possible.

3-3. Operating Procedures. Operating Procedures provide facility specific information about equipment/systems and directions for operating equipment/systems during normal, abnormal, and emergency situations. Accurate operating procedures are a critical resource influencing action of the operations personnel during normal and abnormal operation.

a. Normal Operating Procedures:

(1) Operating Limits. Knowing and understanding the operating limits of major hydropower facility equipment is key to successful and reliable operation of the hydropower facility. Operating limits consist of generator capability curves, operating memos, special conditions, design parameters, maintenance history, etc. All hydropower facilities must have clearly established current operating limits readily accessible for reference.

(a) Capability Curves. A capability curve is defined as a curve that shows boundaries of the area on the kilowatt-kilovar diagram within which a machine may operate continuously. Capability curves are furnished for each installation showing the expected range of operation and including the range of permissible operating voltages. Machines should not be operated outside approved operating boundaries. USACE generators provide Power Marketing Administrations (and associated Transmission Operators) the reactive and voltage control necessary to ensure voltage levels, reactive flows, and reactive resources. These services are provided while operating the generation equipment within their applicable Facility Ratings to protect the equipment. Capability curves define this rating and are, therefore, critical operator requirements for the safe operation of the facility.

(b) The operating limits of other equipment such as cables, buses, reactors, circuit breakers, disconnecting switches, current transformers, and power transformers also should be known. Any one of these may constitute the practical limit in load carrying ability of the unit. On the machine itself, the limits of auxiliary equipment such as exciters or rheostats should be known. The exciter should have sufficient margin while carrying the overload to take care of small fluctuations in load and voltage that may occur with minor system disturbances. In some cases, it may be possible to ease the burden on the exciters of the machine being overloaded by transferring reactive kilovolt-ampere (kVA) to other units of the same system.

(2) Alarm Response Procedures. Responsible operations/maintenance staff should develop alarm response procedures that identify all inputs that initiate annunciator or trouble alarms and the respective response actions.

(3) Control Center and Control Room Operations. The Control Center and Control Room are the coordination points for all operations of equipment (or systems) under the jurisdiction of the operator, including all coordination with the Transmission Operator, Balancing Authority, and System Operators. In the case of multijurisdictional Control Centers, this coordination includes operations between different USACE Districts. Control Centers must have current copies of the Operating Procedures, including Abnormal Operating Procedures (AOPs) and Emergency Operating Procedures, for all facilities that they operate.

(a) Controls: The security plan that controls physical access to the Control Center and Control Room must be posted and easily accessible. The Operations Head (person or persons having supervisory control over the affected operators) is responsible for assuring professional behavior in the Control Center or Control Room. The operations personnel on duty have the authority to restrict access to the Control Center or Control Room and to remove personnel as deemed necessary.

(b) Operations responsibilities: Operations staff operate facility equipment, monitor equipment operating parameters, respond to malfunctions and alarms according to established procedures, and perform administrative tasks.

(c) Operations tasks: log any changes in operating conditions and report abnormal conditions to appropriate personnel for corrective actions; be familiar with the functions and operating limits of facility equipment and systems; be aware of all work that is being performed on equipment (or systems); verify equipment (or systems) can be removed from service without adversely affecting other operating systems or entities; inform the Transmission Operator and other appropriate personnel immediately of any emergency or abnormal condition that affects system operation; manage the Operational Configuration of the facility per approved procedures; and respond to all abnormal and emergency situations per established Standard Operating Procedures (SOPs) and Emergency Action Plans.

(4) For guidance on hazardous energy control programs, please reference ER 385-1-31, The Control of Hazardous Energy.

(5) For guidance on hydropower facility security, please reference AR 190-13, Army Physical Security Program.

(6) Power Plant Inspections. Effective monitoring of equipment is necessary to detect abnormal conditions or adverse trends. Monitoring allows actions to be taken before the equipment malfunctions. Inspections must be conducted periodically and documented per facility requirements as determined by each MSC. Where applicable, a visual inspection of control boards, including a test of the annunciator windows, will be completed to verify indication/annunciation lights are operational. Inspection sheets provide guidance on the extent to which equipment and areas should be inspected. Inspection sheets assist operations personnel during shift turnover, and include acceptable parameters to assist operations personnel in identifying abnormal readings.

(7) Equipment Labeling. A good labeling program that is understood and maintained by operations and maintenance personnel enhances the effectiveness of training. Such a program also helps to reduce errors in operations and errors made by maintenance personnel. Errors can result from incorrect identification of equipment and controls. The labeling program should allow operations and maintenance personnel to identify instrumentation, controls, and equipment needing labels. In addition to equipment, doors to rooms should be labeled to help facility and support personnel to identify rooms and, if applicable, the equipment inside. At a minimum, the following items should be labeled:

(a) Emergency exits, fire alarms, fire protection, and fire extinguishers.

(b) Rescue and first aid equipment.

(c) Circuit breakers and power panels.

(d) Valves should be labeled with a number and name describing the purpose consistent with system drawings.

(e) Piping systems should be labeled with flow direction and contents.

(f) Major plant equipment should be labeled by equipment number and function.

b. Abnormal Operations. For guidance on how to address situations where operations are outside of normal expectations, reference Appendix A.

c. Emergency Operations. In extreme emergencies where a lack of generation might cause power system instability or breakup, it may be necessary to overload machines briefly in excess of the normal loading limit and/or maximum temperature permitted by insulation class. Old machines that have been uprated, new machines (post-1982), and machines under warranty (new, recently rewound or uprated, etc.) should not be operated above rated capacity as uprated, and new machines may not have overload capabilities. When overloading is done, a sacrifice in insulation life must be expected, and the risk of mechanical damage to the machine must be considered. Capability curves also provide insight into which operating parameters are being challenged, thus identifying data points where increased monitoring is required. Reference Appendix A for more guidance on emergency operations.

3-4. Operating Log. An Operating Log must be maintained daily at each USACE hydropower facility in the Remote Control Center or Local Control Room. Completed Operating Logs must be kept as a permanent record in a secure location. Operating Logs are maintained by operations personnel in charge of each shift who must use ENG FORM 2198. Local reproduction of this form and a fillable version is provided on the USACE publications site: https://www.publications.usace.army.mil/Portals/76/Publications/EngineerForms/Eng_Form_2198.pdf?ver=rS3sb1AzCzTanVufnf8KOQ%3d%3d.

a. Each MSC must identify a person or persons with supervisory control over the affected operations personnel to independently review the Operating Log on a regular and reoccurring basis, and any changes resulting from independent review must be explicitly and transparently documented and explained. The Operating Log will be reviewed to verify that each of the activities and entries listed below were correctly entered, entries not made that should have been, and late entry corrections are made as necessary.

b. The Operating Log must document the following activities, at a minimum:

(1) Operations staff on duty.

(2) All operations of waterway equipment including gates, valves, and changes to spillway gate positions.

(3) Communications involving plant operations, switching, Hot Line Orders, Clearances, Special Conditions, alarms, and relay operations. All communications with Transmission Operators must be logged.

(4) Water elevations and releases and operational changes affecting water elevations and releases (unless reported on water supply forms or approved daily record).

(5) Status of auxiliary equipment.

(6) Testing of equipment or gate controls.

(7) Acts of vandalism or other security incidents.

(8) Requests and concurrence to change from normal operations during emergency or abnormal conditions.

(9) Communications network checks and emergency exercises conducted.

(10) The disabling and re-enabling of facility alarms.

(11) Unit start and stop times.

(12) Any equipment failures or malfunctions.

(13) Automatic voltage regulator (AVR), AVR Mode, and power system stabilizer (PSS) change in status, and documentation that the balancing authority was notified of any change in status within 30 minutes.

(14) Line outages.

(15) Callouts.

(16) Any change in unit status (condensing, available, unavailable, etc.).

(17) Status of all major equipment; active clearances, hot line orders, special conditions; and elevations at 0000 hours (or when staffed). Printed reports can supplement Operating Log entries including software programs that are able to generate midnight (0000 hours) reports to capture this information.

(18) Sequence of Events Recorder Data. This information can supplement Operating Log entries either in a printed or electronic format.

Chapter 4
Hydropower Equipment Maintenance and Investment

4-1. Purpose. This chapter establishes guidance for planning, implementation, and reporting on maintenance and investment for all USACE hydropower facilities, to maximize their useful life and reduce near-term routine maintenance costs to meet mission requirements.

4-2. Guidance. The guidance provided in this chapter is intended to aid the enterprise in adhering to the associated policy and ensure hydropower maintenance and investment is conducted in the most consistent manner possible.

a. Generating Unit Importance Factors: The following factors (listed in order of importance) will be used to determine the importance of generating units (and supporting infrastructure such as switchyards). The factors are intended to guide consistent prioritization of maintenance actions and investments.

(1) Unacceptable Safety Risk: Component failure results in impacts to life safety or loss of equipment. This covers risk to both human health and dam safety associated with all project purposes (for example, hydropower, flood control).

(2) Impact to Grid Reliability: The impact of affecting grid reliability at the time of component failure or as a result of component failure.

(3) Impact to Operational Compliance: Component failure results in the inability to comply with a legal and/or environmental judgement or document requiring environmental compliance, mitigation activities, threatened and endangered species activities, cultural resource activities, tribal obligations, or minimum downstream flow.

(4) Non-Reliability Impact to Power Marketing Administrations (PMA) Energy, Capacity, or Grid Services: Component failure would not affect grid reliability but may have an economic consequence to the PMA/Customer, such as replacement energy purchases and lost generation revenue.

(5) Non-Safety Impact to Other Project Operations: Component failure may result in a non-safety impact to other project operations, such as navigation or flood control.

b. Maintenance Standards:

(1) All maintenance must be planned in line with the standards found in Appendix B.

(2) When practical, the maintenance tasks in Appendix B were organized into specific categories, with a "General" category at the top of the list that applies to each corresponding subcategory shown below. To utilize lists that feature a "General" section, combine the General tasks with those shown for the selected subcategory.

(3) Appendix B does not specify how to perform the maintenance tasks. Unless specific guidance is provided by the respective MSC, the tasks must be completed using the industry-accepted best practices (for example, Facilities Instructions, Standards, & Techniques standards or original equipment manufacturer guidance) and in compliance with safety, health, and other applicable requirements.

(4) One of six possible frequency categories is assigned for each task. These categories are: Weekly (W), Monthly (M), Quarterly (Q), Semi-Annual (S), Annual (A), and Periodic (P). The number of years for the Periodic frequency are indicated in the "P" columns. The shortest frequency is shown where more than one of the frequency categories applies to a task.

(5) Follow the guidance provided by the MSC to address equipment and variations not identified within Appendix B.

c. All hydropower maintenance and inspection activities as documented in the Project Maintenance Management Plan must be prioritized in the Facilities and Equipment Maintenance (FEM) system to reflect their relative risk and criticality to reliable hydropower operations. These priorities are used to track maintenance activities and defer work according to the guidance provided by the respective MSC. FEM specifies the following four categories for Job Plans or Work Orders:

(1) Deferrable, low priority.

(2) Normal, for effective operation.

(3) Urgent, stop eventual loss.

(4) Critical, stop immediate loss.

d. At each hydropower project, FEM will contain the following information:

(1) Equipment inventories.

(2) Repair histories.

(3) Inspection reports.

(4) Inspection frequencies.

(5) Standards for equipment maintenance.

e. The control program for FEM will include the following:

(1) Work order and work completion tracking process.

(2) Process for scheduling maintenance.

(3) Process for evaluating maintenance efficacy.

(4) Process for implementing corrective actions in maintenance practices.

(5) Process for sharing corrective actions with other projects.

f. Condition of Hydropower Assets: Condition assessments must be conducted in line with ER 1130-2-554, USACE Condition Assessments. Each MSC must coordinate implementation of an SOP with the Districts and/or local projects that will document the standardized business process and procedures, roles and responsibilities, quality assurance/quality control (QA/QC) plan, assessment frequency, and documentation requirements to be followed within Operations Division (OD) for use and implementation of the Hydropower Asset Management Partnership (hydroAMP) Equipment Assets. The SOP must also incorporate the hydroAMP application into existing maintenance, planning, budgeting, and decision-making structures. For guidance on the use of the hydroAMP tool, refer to the hydroAMP guide provided by the MSC.

g. MSCs must prioritize their nonroutine maintenance, rehabilitation, and modernization projects using an appropriate and currently recognized tool, such as FEM, Hydropower Modernization Initiative (HMI), or Copperleaf C-55, or that considers generating unit importance and asset condition. Each MSC must provide guidance to their Districts on their prioritization tool.

h. Each MSC must submit the following information every 12 months to the HQ Hydropower Business Line Manager:

(1) Summary of investment strategy and project prioritization process.

(2) Table of all prioritized investment projects that includes:

(a) Priority.

(b) Location.

(c) Name.

(d) Hydroelectric Design Center Work Level (if applicable, see ER 10-1-53, Roles and Responsibilities Hydroelectric Design Center).

(e) Estimated project cost.

(f) Estimated (or actual) start and finish dates.

(g) Acquisition strategy (for example, in-house execution, existing contract, new contract).

(3) Graph of projected annual funding needs for all projects over the next 10 years.

Chapter 5
Power Review of Operations and Maintenance

5-1. Purpose. This chapter establishes the guidance for the PRO&M of USACE hydropower facilities.

5-2. Guidance. The guidance in this chapter is intended to aid the enterprise in adhering to the associated policy and contributing to continuous improvement through compliance.

a. Checksheets: The checksheet is the most important review tool and forms the foundation of Annual Hydroelectric Reviews (AHR) and Comprehensive Hydroelectric Reviews (CHR). The checksheets differ for each type of review, but they all cover power facilities in the electrical maintenance, mechanical maintenance, operations, and management specialty areas. Checksheet templates are provided by HQUSACE (or delegate) and posted to an online shared resource website.

b. Annual Hydroelectric Review: The intent of the AHR is to ensure that projects meet minimum requirements of hydropower O&M practices through self-assessment. Specific items, including systemic issues, are identified in the AHR checksheet templates. Systemic issues are those identified as a problem due to issues inherent in the overall system, rather than due to specific, individual, or isolated factors. Systemic issues may be inherent within a District, an MSC, or throughout USACE. HQUSACE (or delegate) identifies these issues and includes them in an annual report, which is submitted to HQUSACE (or delegate) to inform continuous improvement opportunities.

c. Comprehensive Hydroelectric Review Scope: The intent of the CHR is to provide an extensive O&M review of all four specialty areas, confirm resolution of findings from prior AHRs, and highlight systemic problems and successes within a District, an MSC, or throughout USACE.

d. Comprehensive Hydroelectric Review Team: CHRs are conducted by a Review Team appointed by HQUSACE (or delegate), which consists of reviewers and shadows. Each team includes a reviewer for each of the specialty areas; one of the reviewers also serves as the Review Team Lead. Reviewers conduct their specialty area of the review, prepare recommendations, and draft their report sections. For smaller facilities, some specialty areas may be combined for efficiency (for example, one reviewer covering both operations and management). Additional reviewers may be added for very large projects or where multiple projects in a geographical area are combined. AHR checksheets may be requested by a Review Team to prepare for or during a CHR. Preparing checksheets for a CHR can be very time consuming, so adequate time and personnel should be allotted for the task.

e. Comprehensive Hydroelectric Review Team Qualifications: The specific qualifications for each type of Review Team participant are as follows:

(1) Shadow. Must have attended the PRO&M Training Workshop.

(2) Reviewer. In addition to shadow qualifications, reviewers must have participated as a shadow for a reviewer in at least one review, received a recommendation from the reviewer and the corresponding Review Team Lead, received a recommendation from the MSC Hydropower Business Line Manager, and received approval from HQUSACE (or delegate).

(3) Review Team Leads. In addition to reviewer requirements, Review Team Leads must have performed at least one review, received a recommendation from their Review Team Lead, received a recommendation from the MSC Hydropower Business Line Manager, and received approval from HQUSACE (or delegate).

f. Funding.

(1) Review Costs. Funding for CHRs and AHRs is the responsibility of the project. CHR costs applicable to specific projects (Spell out introductory phrases ("for example," "including," "such as") in parentheticals rather than using abbreviations. See DA Pam 25-40 page 19.., site visit travel costs and labor for pre-visit preparation, site visit, and report preparation) are funded by a direct charge process so that a project pays for a review only in the year that it is conducted.

(2) Reviewers from Other Agencies. At times, reviewers from other agencies may be used to strengthen the review; they are also directly funded by the project.

(3) Shadow Costs. Labor and travel costs of shadows are provided by the shadow's duty station. Sometimes, shadows from other agencies attend the reviews with permission of the Review Team Lead and Site Review Coordinator; these shadow costs are the responsibility of those agencies.

(4) Observers. On occasion, agency representatives or other individuals (for example, Power Marketing Administration representatives, customers, National Hydropower Business Line Manager) may attend a CHR as an observer. These costs are covered by those agencies or the applicable offices. The MSC, in coordination with the Review Team Lead, approves all observers.

(5) Estimated Costs. Estimated costs of reviews vary according to the size of the facilities being reviewed. Size category definitions, classification of specific reviews by size, and estimated costs are provided by HQUSACE (or delegate).

5-3. Responsibilities. A successful PRO&M requires active participation at every organizational level. The following are responsibilities of the organizations and individuals involved in the PRO&M program:

a. HQUSACE (or delegate).

(1) Provide oversight of the PRO&M program.

(2) Approve reviewers and team leads and maintain a master list of approved personnel available for CHRs. Review team leads must be selected from outside the MSC being reviewed.

(3) Transmit an annual memorandum to the MSCs defining any delegation of responsibility for conducting the reviews and identifying CHRs scheduled for that fiscal year.

(4) Track completion, coordinate, finalize, distribute, and post CHR reports.

(5) Maintain PRO&M program information and documents, including CHR report templates and checksheet templates. Track and monitor the costs associated with conducting reviews.

b. MSCs.

(1) Assist HQUSACE (or delegate) in scheduling CHRs.

(2) Issue the 120-day memorandum to the District.

(3) Ensure AHRs are conducted annually and are completed in a timely manner.

(4) Provide review and oversight of AHRs.

(5) Submit AHRs to HQUSACE (or delegate) once approved.

(6) Provide oversight and status update of AHR and CHR recommendations and submit them to HQUSACE (or delegate).

(7) Provide training candidate recommendations to HQUSACE (or delegate).

(8) Review CHR report before finalization.

(9) Provide a Site Review Coordinator.

c. District Offices.

(1) Budget for the AHR and CHR as required.

(2) Respond to the 120-day memorandum.

(3) Recommend individuals for PRO&M training and shadow opportunities.

(4) Support the PRO&M program including allowing District/Project staff to serve as Review Team members.

(5) Provide a corrective action plan and tracking sheet updates to the MSC for the CHR findings.

d. Project Offices.

(1) Complete AHRs as required.

(2) Provide funding for CHRs.

(3) Enter and track Category 1 and 2 findings in FEM.

(4) Support the PRO&M program including allowing Project staff to serve as Review Team members.

e. Review Team Lead for the CHR performs these duties in addition to those of a reviewer:

(1) Leads the Review Team through all phases of the review including acquiring and distributing drawings, checksheets, and other data.

(2) Provides the cost estimate of the review to the MSC Hydropower Business Line Manager.

(3) Works with the Site Review Coordinator to develop the agenda and ensure that the onsite visit meets the needs of the Review Team and project personnel.

(4) Facilitates the CHR report preparations, making sure the Review Team understands the report template, editing the report for consistency, and ensuring that any comments received are considered.

(5) Provides the final signed report to HQUSACE (or delegate). HQUSACE (or delegate) is available to assist the Review Team Lead in organizing, planning, and following up after the review.

(6) Provides shadow feedback to HQUSACE (or delegate).

f. The Reviewers for the CHR will be selected by HQUSACE (or delegate) from outside the District being reviewed. Reviewers perform these duties:

(1) Conduct the review in their specialty area(s).

(2) Draft their report sections, including recommendations.

(3) Mentor shadows during the review.

(4) Provides shadow feedback to the Review Team Lead.

g. A shadow participates fully in a CHR review, working with a reviewer and fulfilling duties as assigned. Shadows should have technical expertise in the specialty area they are reviewing. Generally, shadows are chosen from outside the District being reviewed.

h. The Site Review Coordinator in a CHR review works with the Review Team Lead to coordinate logistics and ensure that all aspects of the review are accomplished, including collecting and transmitting drawings, checksheets, and other required data.

5-4. Comprehensive Hydroelectric Review Recommendations.

a. Category 1 recommendations involve the correction of severe deficiencies where immediate and responsive action is required to ensure the following:

(1) Structural integrity (operating equipment necessary to prevent catastrophic failure).

(2) Compliance with legal or regulatory requirements: Power-related safety practices (necessary to protect the life or health of employees, visitors, or the public); entities regulating power system reliability/stability (for example, NERC Regional Reliability Organization).

b. Category 2 recommendations cover a wide range of deficiencies where action is needed to:

(1) Prevent or reduce further damage.

(2) Preclude possible structural failure or operational disruption.

(3) Meet mandatory requirements of safety, management, operational, maintenance, or industry standards.

c. Category 3 recommendations are considered to be sound and beneficial suggestions to improve or enhance O&M.

d. Prior to making a recommendation, the Review Team should have ongoing discussions with the project regarding the proposed recommendation. The project may have information that was not available to the reviewer. Before determining that a recommendation should be categorized under Category 1, the Review Team should have discussions and reach a consensus to ensure consistency with the Category 1 definition.

e. A unique identifying number is assigned to each recommendation resulting from a CHR. The identifying number defines the Project (see Appendix C), calendar year of the review in which the recommendation is made, followed by C for comprehensive; a letter designating the specialty area of the recommendation; the category of the recommendation; and a unique, sequential identifier (for example, A, B, C).

(1) Specialty Area Designators. The following specialty area designators are used to sort data (for example, for deferred maintenance reporting): E = electrical maintenance; M = mechanical maintenance; O = operations; G = management.

(2) The identifying number for the first Category 2 mechanical maintenance recommendation at project XXX resulting from a CHR conducted in calendar year 2015 is XXX-2015C-M-2-A. The second Category 2 mechanical maintenance recommendation from this same review would be XXX-2015C-M-2-B, and so on.

f. Category 1 and 2 recommendations must be substantiated by a reference to a standard. A standard cited in a Category 1 or Category 2 recommendation should provide as much detail as reasonable to allow the specific requirement(s) to be located (for example, Preventive Maintenance Tasks for Breakers, Low Voltage Circuit Breaker [Under 600V], Task #7), and it should be in effect at the time of the review. Category 3 recommendations should refer to a sound best practice when one is applicable.

g. Before final approval of the CHR report, every effort will be made to resolve disagreements regarding report findings or recommendations informally between the Review Team, Site Review Coordinator, District, and MSC staff. Where disputes cannot be resolved at this level, HQUSACE (or delegate), in coordination with the MSC Hydropower Business Line Manager, advises the National Hydropower Business Line Manager who makes a determination.

h. All CHR Category 1 and Category 2 findings are tracked in the USACE Maintenance Management System: Facilities Equipment and Maintenance (FEM) system.

(1) An individual work order is required for each Category 1 and Category 2 finding. The following fields must be entered in each work order:

(a) The local work type field must be Power Review.

(b) Enter the following in the description field: Power Review Finding: Unique Identifying Number (for example, Power Review Finding: XXX-2015C-M-2-A).

(2) The status of a recommendation is identified by one of the following (or MSC approved surrogate):

(a) APPROVED – This status includes recommendations that have not been started but are ready to begin execution of the remedy.

(b) IN PROGRESS – This status indicates the recommendations are actively being worked.

(c) CLOSED – This status includes those recommendations for which all work has been accomplished to rectify the deficiency found during the review, and the proper documentation and coordination has occurred to complete the recommendations.

(d) CANCELLED – This status includes those recommendations that a subsequent Review Team recommends for deletion based on sound technical judgment or changes in conditions or standards.

i. Completing Recommendations.

(1) Category 1. Based on the severity of the deficiency and condition at the time of the review, the Review Team may prescribe an appropriate timeframe for completing the recommendation. Suggested remedial measures are discussed at the exit briefing and included in the CHR report. Within 30 days following receipt of Category 1 recommendations, the Project will provide plans and a schedule for completing them to the District Chief, Operations Division, MSC Hydropower Business Line Manager, and HQUSACE (or delegate).

(2) Category 2. Within 180 days following receipt of Category 2 recommendations, the Project will provide plans and a schedule for completing them to the District Chief, Operations Division, MSC Hydropower Business Line Manager, and HQUSACE (or delegate). Category 2 recommendation actions are encouraged as soon as possible following receipt of the CHR report.

(3) Category 3. Category 3 recommendations are to be considered prior to the next AHR.

(4) Recommendations for District Office Resolution. Some recommendations are directed to the District Chief, Operations Division, for resolution. These are usually systemic in nature, affect more than one facility, and require technical investigations or policy decisions.

Chapter 6
Hydropower Craft Training Program

6-1. Purpose. This chapter establishes the guidance for the apprenticeship training program for hydropower trainee advancement to their hydropower facility target positions as enumerated in the USACE power rate schedules.

6-2. Guidance. It is USACE policy to adhere to the following guidance.

a. The training for academic subjects is provided by classroom instruction, e-learning, or correspondence courses. Hydropower facility equipment training is provided through classroom (or equal) instruction. On-the-job training is achieved by orderly progression through practical assignments closely related to academic subjects and plant equipment classroom instructions. The training program consists of:

(1) A four-year training and development program required for all entrants who do not have previous hands-on experience, and academic or vocational education beyond the entry level requirements.

(2) Trainees may make a written request for reductions in time required to complete the training program. The training committee will review this request based on prior experience or training. If the training committee has been delegated authority to do so, they will approve or deny the request. If the training committee has not been delegated this authority, the request will be brought before the District Commander for approval. The trainee is responsible for providing the satisfactory proof of experience or training cited as creditable for a reduction in training time.

(a) Acceptable proof includes academic transcripts and course descriptions from accredited vocational schools, colleges or community colleges, and statements from former supervisors outlining previous work experiences, level of responsibility, and performance appraisal.

(b) Specialized military experience relating to hydropower may also serve as acceptable proof for a reduction in training time. USACE is required to evaluate such experience for all veterans entering the program, whether the veteran requests it or not (38 CFR § 21.4254(c)(4)). However, the veteran is under no obligation to take a reduction in training time. Only one reduction will be granted. If the trainee is granted a reduction in time, the training program manager will prepare a training schedule. The training schedule will ensure that the trainee has an opportunity to develop the same skills and knowledge by the end of the reduced training period as a trainee would have received in the full training program. This training schedule must be approved by the training committee. Trainees who are granted a reduction in training time are required to pass all phase evaluations up to their target position.

(3) Each trainee will be asked to state a preference for the craft specialty desired. Depending on the needs of hydropower facilities and the trainee's aptitude and talents, the trainee will be assigned a craft specialty, subject to the approval of the Hydropower Training Committee, before the beginning of the specialization phase. The Hydropower Training Committee will document the basis on which assignment and approval was based. The craft may be indicated in the recruitment announcement based on the USACE needs.

(4) If feasible, trainees should be transferred between projects while in the training program to broaden their experience.

(5) Training sites should be chosen from the larger and more complex projects in the MSC.

(6) Consideration is given to anticipated retirements, changes in mission, and new projects in various stages of planning and construction when determining the number of new hydropower trainees.

(7) Any deviation from the standard four-year program as stated herein, or material changes in classroom subjects, must be submitted to HQUSACE (CECW-CO). No such changes will be incorporated without prior approval of HQUSACE (CECW-CO).

b. The training program follows a set schedule:

(1) General: The first year of the training program consists of approximately 60% on-the-job training at a USACE hydropower facility and 40% training in trade theory and closely related academic subjects. The next three years of the program consist of approximately 80% on-the-job training at a USACE hydropower facility and 20% training in trade theory and closely related academic subjects.

(2) Academic Instructions: Craft persons are required to know the basic physical principles of the equipment they use. They are also required to read and understand reasonably complex written instructions and to write legible, meaningful reports. Instructions in academic subjects should, preferably, be provided by professional teachers. This could be accomplished through a local school system if it is located nearby and is easily accessible. If professional classroom training is not practical because of geographic distance, then correspondence courses or other delivery methods covering the same general subjects should be provided to the trainee.

(3) Plant Equipment Study: The plant equipment study is designed to provide a trainee with the theory and operation of the hydropower plant equipment. Appendix D lists the topics for formal instructions. The theory portion of the instructions may be obtained through e-learning or correspondence courses, subject to the approval of the Hydropower Training Committee. However, a qualified trade theory instructor or craft person must be provided to the trainees to ensure that the trainees are receiving the best quality instructions and counseling.

(4) On-the-Job Training: This portion of training is critical. Work habits, methods, and techniques developed in this phase of training can make the trainee an efficient and effective craft person. The hydropower training program manager, in consultation with power plant managers, will ensure an on-the-job schedule for each trainee is prepared (see Appendix D). The trainee will complete all of their scheduled on-the-job training tasks for the assigned phase of training and work on as many jobs as practicable, keeping in mind the importance of completing a task from start to finish. Also, the trainee will be assigned to work with craft persons who have specialized capability for the assigned task.

(5) Time for Studying: Academic studying should take place primarily after duty hours. However, an average of 10 hours per week is permitted, if approved by the supervisor, for studying of academic coursework during normal duty hours, provided plant workload permits it. Testing to measure academic progress will be accomplished during normal duty hours.

c. Each trainee's academic and on-the-job progress will be continually monitored by the instructors and qualified craft personnel. The purpose of the evaluation is to assess the trainee's progress and the effectiveness of the instructional process. These evaluations are necessary so that any incipient problems can be exposed at the earliest possible time.

d. At the end of each training phase (approximately six months), every trainee will be evaluated by the training committee. The evaluation will have a written portion, an oral portion, a demonstration of practical skills, and will cover both academic and on-the-job portions of the program. These evaluations are used as part of the procedure to assess a trainee's progress for determining fitness to remain in the program, and as an input to the trainee's performance appraisal. The minimum requirement for passing a phase evaluation is a score of 70% overall and 70% on each correspondence school instruction unit or classroom course. Upon satisfactory completion of the phase evaluation and other performance requirements, the trainee is advanced to the next training phase.

e. Each trainee is responsible for maintaining satisfactory progress in academic studies and on-the-job training. The evaluations determine the trainee's progress:

(1) Failing Periodic Evaluations. If the results of a periodic evaluation are unsatisfactory, the appropriate supervisor will discuss the results with the trainee and determine reasons for unacceptable progress. The trainee will be provided with appropriate assistance and may be given a make-up evaluation.

(2) Failing Phase Evaluations. If the result of a phase evaluation is unsatisfactory, the training committee will inform the appropriate supervisor. The supervisor will notify the trainee in writing of the failure, inform the trainee of the specific deficiencies, what the trainee must do to overcome the deficiencies, provide time for the trainee to study per MSC/District policy, and provide the trainee with the appropriate assistance. The training committee will re-administer the phase evaluation. Failure of two consecutive phase evaluations or three nonconsecutive phase evaluations any time during the training period will require removal of the trainee from the training program consistent with the Office of Personnel Management (OPM) regulations. The hydropower training committee retains discretion on removal actions under unique circumstances.

f. Trainees are responsible for meeting and maintaining standards of federal employment in their academic on-the-job performance and personal work conduct. They are responsible for learning the study material and doing the work required in the trade without hazard to themselves or other workers.

g. The craft person to whom the trainee is assigned for on-the-job training is responsible for overseeing the trainee's work assignments. They make every effort to ensure that the trainee receives the best possible training, and guide, monitor, and evaluate the trainee's work and progress on a daily basis. They also provide to the training program manager a formal evaluation of the trainee at the completion of trainee's rotational assignment.

h. Hydropower training program managers provide assistance and guidance to instructors, as needed, and are responsible for maintaining training records in line with HR guidance. The instructors are responsible for keeping the training program manager appraised of the trainee's performance, and for keeping trainees informed of their progress in the classroom.

i. Every hydropower employee should receive 40 to 80 hours per year of craft-specific, specialized training. This continuing education ensures that employees maintain competence in their craft and keeps them abreast of new best industry practices and guidance.

Appendix A
Facility Abnormal Operations

A-1. Purpose. The following information is generic in scope and is provided as example events and/or conditions to consider when creating site-specific response procedures for abnormal and/or emergency operations. Some emergency events are also abnormal events and should have appropriate AOPs. The Emergency Operating Procedure defines emergency conditions and then coordinates and prioritizes the mitigation actions of the AOPs. The information provided in this appendix is summarized in the Table A-1.

Table A-1
Topics Covered in Appendix A

Section	Section Title
a	Flooding in the Facility
b	Loss of Station Service
c	Loss of Plant DC Control and Protection
d	Loss of Plant Control Alternating Current (AC)/Uninterruptible Power Supply
e	Loss of Air Systems
f	Generator and Transformer Breaker Abnormal Operations
g	Plant Running Isolated (Not Connected to Grid)
h	Carbon Dioxide Discharge
i	Differential or Ground Relay Operation
j	Overcurrent Relay Operation
k	Overvoltage Relay Operation
l	Loss of Generator Field
m	Abnormal Operation of the Voltage Regulator
n	Stator Winding High Temperature
o	Main Field Winding High Temperature (If Applicable)
p	Generator Bearing Temperature Alarm or Shutdown Relay Operation
q	High or Low Thrust Bearing Oil Level Alarm
r	Generator Air Cooling Water Alarm
s	Thrust Bearing Cooling Water Alarm
t	Thrust Bearing Temperature Alarm or Shutdown Relay Operation
u	Loss of Water Supply to Packing Gland
v	Loss of Turbine Seal Lubricating Water
w	Failure of Turbine/Generator Bearing Oil Pumps
x	Loss of Permanent Magnet Generator (PMG)/Speed Signal Generator (SSG)
y	Abnormal Operation of Governor
z	Loss of the Restoring Cable (Mechanical Governor)
aa	Loss of Gate Position Indication (Digital Governor)
bb	Low Governor Oil Pressure Alarm and Shutdown Relay Operation
cc	Overspeed or Runaway
dd	Turbine Pit High Water

Section	Section Title
ee	Failure of Gate Shear Pin
ff	Unusual Mechanical Noise or Vibration
gg	Transformer Differential Relay Operation
hh	Transformer High Temperature Alarm or Shutdown Relay Operation
ii	Transformer Oil Flow Failure
jj	Sudden Pressure Relay
kk	Transformer Oil and Gas Alarm
ll	Low Oil Pressure/Level for Transformers with Conservator Tank

a. Flooding in the Facility.

(1) If failure of a penstock, scroll case door/gasket, draft tube door/gasket, or head cover occurs:

(a) Sound the plant evacuation alarm.

(b) If the failed penstock or head gate is identified, close the specific unit penstock gate consistent with local facility instructions.

(c) If the failed penstock or head gate is unknown, close all penstock gates to protect the facility in line with local facility instructions.

(d) If failure of the sump pumps occurs, use of a site-specific eductor or temporary sump pump is required.

NOTE: Failure of a penstock, scroll case door/gasket, draft tube door/gasket, or head cover will cause catastrophic damage to the facility.

b. Loss of Station Service.

(1) The loss of Station Service can cause many significant problems in a facility including:

(a) Loss of generator auxiliaries, including cooling water, lube oil pumps, and governor oil pumps.

(b) Flooding from loss of sump pumps.

(c) Loss of power to emergency equipment (site-specific, fire pumps, alarms, etc.).

(d) Loss of the ability to bypass water.

(e) Loss of station air systems.

(f) Loss of transformer cooling.

(g) Loss of battery chargers (site-specific plant battery, supervisory control and data acquisition [SCADA] battery, uninterruptible power supply [UPS] battery).

(h) Loss of power to restore penstock intake gates.

(i) Loss of oil pressure systems.

(j) Exit issues, including elevator failures.

(k) Loss of facility services including water, wastewater, lighting, and heating, ventilation, and air conditioning (HVAC).

NOTE: A loss of station service may cause a loss of Main Unit Auxiliaries. This could cause overheating of the generator windings and lube oil system and may cause bearing damage. If you have designated Main Units to provide station service, you may want to continue to operate them to allow the re-energization of station service.

---

(2) For black start plants, initiate black start procedures.

(3) Stop any unit unwatering operations to conserve sump capacity.

(4) For a complete failure of station service from a major fault or fire, perform the following:

(a) Shut down Main Units to prevent damage caused by a loss of auxiliaries.

(b) Close the intake gates.

(c) Drain the unit penstocks. This will prevent unit creep once station service air pressure is lost and will limit inflow to plant sumps.

(d) Manually block the unit brakes (if applicable).

(5) If the units trip, verify that the units shut down completely.

(6) If you have manually operated eductors, operate them to control sump levels.

CAUTION: A loss of power may prevent the operation of plant eductors if they are operated or water is supplied from the penstock. Facility should consider alternative means to remove water on a loss of power.

---

(7) Ensure that emergency generators have started. Ensure that critical loads are being fed and monitor the generator for proper operation.

(8) If a Main Unit is left on to assist with restoring station service:

(a) Operate the unit at minimum load, but not condensing.

(b) Take unit off automatic generation control (AGC).

(c) Minimize load changes to conserve governor pressure.

(d) Monitor battery and reduce direct current (DC) loads to conserve energy.

(e) Monitor bearing metal/oil and generator air temperatures. Reduce load or shut down the unit as necessary to reduce temperature rise.

(f) Monitor transformer temperatures and reduce loading as necessary to minimize temperature rise.

(9) Verify that personnel are not stuck in elevators.

(10) Implement facility procedures to maintain downstream flows.

(11) Conserve station air system by securing maintenance operations that consume air.

c. Loss of Plant DC Control and Protection.

(1) Loss of the DC system will cause loss of control and protection circuits.

(2) Check that the units have tripped and are shutting down.

(3) Ensure that generator breakers are open. Manually trip breakers that have not opened.

CAUTION (Site-Specific): Manually opening a large switchgear breaker may be hazardous. Facilities should develop site-specific procedures to respond to a generator breaker trip failure.

---

(4) Ensure that transformer breakers are open. Manually trip breakers that have not opened.

(5) Secure the Main Units as follows:

(a) Close the intake gates.

(b) Drain the unit penstocks by cracking open the unit wicket gates.

(c) Leave wicket gates slightly open to drain off intake gate leakage.

(d) Manually block the unit brakes.

(6) Investigate loss of DC system.

d. Loss of Plant Control Alternating Current (AC)/Uninterruptible Power Supply.

(1) The loss of the Plant Control AC system may cause the loss of the following (site-specific) systems:

(a) SCADA.

(b) Instrumentation/metering.

(c) Digital governors.

(d) Fire alarms/detection.

(e) PSS.

(2) If all control room indication of units is lost (metering and SCADA), dispatch personnel to locally monitor and/or operate units (site-specific or Continuity of Operations [COO] Plan).

(3) If units are SCADA operated and UPS power to SCADA is lost, initiate procedures to take manual operation of units.

(4) If the generation is not essential, consider shutting the units down.

(5) If generators must remain operational, minimize load changes.

(6) Investigate loss of AC plant control.

e. Loss of Air Systems.

NOTE: Some facilities have separate systems for governors, breakers, and station air.

(1) If a major failure occurs in the station air system piping:

(a) Secure station air compressors.

(b) Secure condensing operations.

(c) Shut down units beginning to creep and ensure penstock gate closure and thrust pump starting.

(d) Isolate the air leak and restore the air system.

(2) If air compressors have failed:

(a) Implement air system cross-connect procedures or emergency air supply.

(b) Investigate the failure of the air compressors and restore system.

(c) Take manual control of all air-operated cooling water control valves until station air system is restored.

(3) If a loss of unit governor air occurs, minimize load changes to conserve governor pressure. The main units will trip, and the intake gate will close at a low governor pressure (site-specific).

(4) If a major failure occurs in the governor air system piping:

(a) Secure governor air compressor(s).

(b) Isolate piping failure and restore system.

(5) If governor air compressor(s) have failed, perform the following:

(a) Implement governor air system cross-connect procedures or emergency air supply (site-specific).

(b) Investigate the failure of air compressor(s) and restore system.

NOTE: Loss of a generator breaker operating the air may cause the breaker to lock out, open, or close breaker (site-specific).

(6) If Unit Breakers operating the air is lost, minimize breaker operations to conserve operating air.

(7) If a major failure occurs in Unit Breaker air system piping:

(a) Secure breaker air compressor(s).

(b) Isolate piping failure and restore system.

(8) If Unit Breaker air compressor(s) have failed, perform the following:

(a) Implement governor air system cross-connect procedures or emergency air supply procedure (site-specific).

(b) Investigate the failure of breaker air compressor(s) and restore system.

f. Generator and Transformer Breaker Abnormal Operations.

(1) A breaker failure relay (BFR) indicates a failed breaker to the Operator (site-specific).

(2) The BFR should operate appropriate breakers to isolate the failed breaker.

(3) If the breaker fails to open or to be isolated, open the switchyard breaker or manually open the breaker (site-specific).

CAUTION: Do not open breakers manually with low sulfur hexafluoride (SF_6), air, or oil pressures. This could cause catastrophic breaker failure and personal injury.

CAUTION (Site-Specific): Manually opening a large switchgear breaker may be hazardous. Facilities should develop site-specific procedures to respond to a generator breaker trip failure.

NOTE: Breakers should have a breaker failure scheme.

(4) If a breaker fails to operate:

(a) Check whether the red and green lights on the breakers are operational. This verifies continuity through the closing and tripping circuits.

(b) Check oil/air/SF_6 pressure.

(c) Check synchronizing circuit, local/remote switch (site-specific).

(d) Check that control power is available.

(5) If a loss of SF_6 occurs, follow safe handling procedures for SF_6 equipment.

(6) Low breaker operating pressure will prevent the operation of air blast breakers. The low pressure alarm operates at (site-specific).

(7) For low breaker air pressure, the Operator will do the following.

(a) Attempt to locate and isolate the leak.

(b) Check the breaker air compressor status, including the power supply and fuses.

(c) Implement air system cross-connect procedures or emergency air supply (site-specific).

g. Plant Running Isolated (Not Connected to Grid).

(1) In this condition, the facility is a step closer to a blackout condition.

(2) Immediately maintain station service voltage and frequency. Failure to do so can cause electrical equipment failures.

(3) Plant staff should minimize the use of non-essential electrical equipment (compressors, cranes, pumps, etc.).

(4) Initiate recovery procedures with Power Marketing Agency (site-specific).

h. Carbon Dioxide Discharge.

CAUTION: Do not enter lower areas of the facility where carbon dioxide (CO_2) could collect. Time should be allowed for CO_2 to dissipate.

Do not enter areas without a self-contained breathing apparatus (SCBA) and air monitor.

NOTE: Reset the initiating devices or relays prior to resetting the CO_2 system (site-specific).

(1) Verify operating unit shutdown.

(2) If the plant is manned, operating personnel should monitor the generator for signs of a fire. If fire is present, additional CO_2 should be discharged.

(3) Plant personnel should be warned of the danger of CO_2 concentrations in low places and should evacuate lower elevations of the facility for at least 30 minutes.

(4) Entries into these areas must be in line with established Activity Hazard Analysis (AHA). Anyone entering these areas should carry an SCBA and an air monitor.

(5) Evacuate the facility or lower areas of the plant (site-specific).

(6) Re-entry will be performed according to Project Re-entry Plan.

i. Differential or Ground Relay Operation.

(1) When a unit is shut down by operation of the differential or ground relays, the Operator should take the following action:

CAUTION: **DO NOT** restart the unit until the problem is identified and corrected. Failure to identify and correct the problem could cause permanent damage to the windings and core.

(a) Always ensure that the unit has come to a complete stop.

(b) Ensure that CO_2 has discharged (site-specific details) and determine if additional discharges are required.

(c) Refer to the section on CO_2 discharges.

(d) Notify the Facility Manager or Operations Head.

(e) The unit should not be restarted until the cause of the shutdown has been investigated and repaired, if necessary.

j. Overcurrent Relay Operation.

(1) Overcurrent relays are not likely to operate on overload unless the overload is accompanied by a very high reactive load.

(2) The relay protects the generator against sustained excessive currents and against external faults that do not clear, such as switchyard bus faults or line faults.

(3) If a unit overcurrent relay operates, ensure that unit lockout and unit shutdown occur.

(4) When a single unit trips on overcurrent, the Operator should check for trouble in the excitation system.

(5) When several units trip simultaneously on overcurrent, the Operator should check for the possibility of a switchyard bus fault or a line fault that failed to clear.

(6) The unit may go back online as soon as the problem is corrected.

k. Overvoltage Relay Operation.

(1) The generator overvoltage relay provides protection against dangerously high generator voltages.

(2) If a unit overvoltage relay operates, ensure that unit lockout and unit shutdown occur.

(3) If the unit was tied to the grid and supplying a significant voltage support, a grid disturbance could have caused the relay actuation.

(4) The excitation system should be inspected to determine the problem.

l. Loss of Generator Field.

(1) When loss of the generator field occurs with the unit connected to the system, leading reactive flows into the machine to help maintain the generator terminal voltage.

(2) If a unit loss of field relay operates, ensure unit lockout and unit shutdown occur.

(3) The following should be inspected to determine the loss of field:

(a) Excitation system.

(b) Field breaker.

(c) Collector ring.

(d) Brush assembly.

(e) Associated bus work.

m. Abnormal Operation of the Voltage Regulator.

CAUTION: Voltage regulators should not be operated in manual or current mode without an Operator present or for extended periods of time. The Local Control Area must be notified of all units that are being operated with the voltage regulator in manual.

---

(1) When abnormal conditions occur in the voltage regulator or the excitation system, the voltage regulator should be taken out of service by shutting the unit down.

(2) The voltage regulator may automatically switch to the manual mode on failure of the automatic voltage regulator.

(3) The voltage regulator and excitation system should be inspected and the problem corrected before restarting the unit.

n. Stator Winding High Temperature.

(1) The stator winding temperature high limit is monitored by embedded temperature detectors and are set at (site-specific) degrees Celsius.

(2) Remotely operated units at facilities that are currently unmanned should be unloaded first to reduce temperatures to a safe operating limit. If load reduction does not reduce high temperatures, shut down the unit.

(3) While high stator temperatures should not occur except at rated load and above, Operators should watch for higher than normal temperatures at lower loads.

(4) When abnormal temperatures occur, Operators should check for:

(a) Proper generator air-cooling water flow (site-specific).

(b) Hot spots.

(c) Air-locked coolers.

(d) High field current or temperature.

(5) If the temperature exceeds the maximum of (site-specific) degrees Celsius, the load and/or reactive should be reduced to bring the temperature back to the limit. Raising the generator voltage slightly to reduce armature current may be helpful, especially if the reactive is on the leading side.

(6) If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

o. Main Field Winding High Temperature (if applicable).

(1) The main field winding temperature may be calculated from rotor current (facility specific).

(2) Remotely operated units whose facility is also currently unmanned should have the field current reduced to bring temperatures to a safe operating limit. If lowering the field current does not reduce high temperatures, shut down the unit.

(3) When the indicated field temperature reaches (site-specific) degrees Celsius, the Operator should take the following action:

(a) Check the stator temperature and the field current.

(b) If the stator temperature is below its limit of (site-specific) degrees Celsius and the field current is below its limit (site-specific), it is unlikely that the field temperature is too high.

(c) If the field current is above the limit or if the stator temperature is too high, reduce the generator reactive and megawatt load.

(d) High temperature may be an indication of an increase in the winding resistance as a result of the development of high resistance joints in the connections between coils. If this is suspected, the Facility Manager or Operations Head should be notified.

p. Generator Bearing Temperature Alarm or Shutdown Relay Operation.

(1) The generator bearing high temperature alarm actuates at (facility specific) and will cause a unit shutdown at (facility specific).

(2) If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.

CAUTION: Do not use emergency shutdown (SCADA or control switch). This will open the generator breaker before the gates are closed, causing an increase in speed, which might do further damage to the bearing.

(3) Remotely operated units at facilities that are currently unmanned should be immediately shutdown.

(4) An immediate inspection should be made, including a check on bearing temperatures, oil flows and levels, and cooling water flow. The Operator also should check for any unusual noises or vibration of the unit.

(5) If the bearing temperature shows a fast temperature rise of (site-specific) degrees Celsius or more above normal with other temperatures near normal, the unit should be shut down immediately.

(6) If the temperature recorder shows a rather slow temperature rise, check to make sure that cooling water flow and oil level is normal and reduce unit load.

(7) If temperatures continue to rise, the unit should be shut down using normal procedures.

(8) For a slow rise in temperature, the Operator should be alert for indicator failures. When the bearing temperatures actually rise, the change is likely to show up on several indicators, rather than on only one.

(9) SCADA or other temperature indicators may be used to validate the high temperature.

(10) If a high temperature relay operates, ensure the unit lockout and a unit shutdown occurs.

(11) If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

q. High or Low Thrust Bearing Oil Level Alarm.

(1) The generator high oil level alarm actuates at (facility specific) and the low oil level alarm actuates at (facility specific).

(2) If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.

(3) Remotely operated units at facilities that are currently unmanned should be immediately shut down.

(4) If the oil level is high:

(a) Check for an oil cooler leak.

(b) Check the sight glass for milky appearance and take an oil sample from the bottom of the bearing sump.

(5) If there is considerable water in the oil, the unit should be unloaded and shut down using normal procedures.

(6) If the oil level is low:

(a) The thrust bearing temperatures should be monitored.

(b) Check for leaks.

(c) If a large leak is discovered, unload the unit and shut it down until the condition can be corrected.

(d) If there is no indication of a leak, oil should be added.

(7) In cases of abnormal oil levels, all supply and drain valves should be checked for leaks.

(8) If the cause of the high/low oil level is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

r. Generator Air-Cooling Water Alarm.

(1) The air-cooling water alarm is energized by:

(a) Low cooling water flow (site-specific).

(b) Low pressure (site-specific).

(c) High-discharge air thermometers (site-specific).

(2) When the alarm is energized, the Operator should check cooling water flow and discharge air temperatures.

(3) If the cooling water flow is below normal, check that all supply and discharge valves are open.

(4) Check that water supply pressure is greater than (site-specific). If supply pressure is low, check pumps and strainers.

(5) A single high-discharge air temperature greater than (site-specific) is an indication of an air-locked cooler or a closed isolation valve.

(6) If the stator temperature gets too high, it may be necessary to reduce load to keep the temperature within limits.

(7) If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

s. Thrust Bearing Cooling Water Alarm.

(1) Thrust bearing cooling water alarm actuates at (site-specific).

(2) Remotely operated units at facilities that are currently unmanned should be immediately shut down.

(3) An immediate inspection should be made to check cooling water flow greater than (site-specific). The Operator should also check for any unusual noises or vibration of the unit.

(4) Ensure that all supply and discharge valves are open and header pressure is greater than (site-specific).

(5) If cooling water flow cannot be restored, the unit should be shut down.

t. Thrust Bearing Temperature Alarm or Shutdown Relay Operation.

(1) The turbine bearing temperature alarm will be energized by any of the following:

(a) Bearing temperature recorder (site-specific).

(b) Bearing metal temperature indicating thermometer (site-specific).

(c) Bearing oil temperature indicating thermometer (site-specific).

(2) If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.

(3) Remotely operated units at facilities that are currently unmanned should be immediately shut down.

(4) When the alarm is energized, the Operator should check bearing temperatures.

(5) If any temperatures are found to be above normal, inspect the bearing cooling water and the oil supply system to determine the cause of the high temperature.

(6) The turbine bearing can be operated temporarily without cooling water if the bearing temperature does not exceed (site-specific).

(7) If the cooling water supply is normal, the Operator should check the shaft runout. The Operator also should check for any unusual noise or a vibration that might increase the bearing friction.

(8) If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

u. Loss of Water Supply to Packing Gland.

(1) The shaft packing requires a small amount of cooling water to help lubricate the packing and to prevent heating and seizing of the packing. The low flow alarm actuates at (site-specific).

(2) Remotely operated units at facilities that are currently unmanned should be immediately shut down.

(3) The Operator should check the flow of gland water on each inspection.

(4) If the cooling water fails and the packing gets hot, the Operator should first try to restore the cooling water flow. If this cannot be done, the unit should be unloaded and shut down to prevent possible damage to the shaft sleeve.

v. Loss of Turbine Seal Lubricating Water.

(1) Some generators use seal water only during motoring/condensing. If the seal water fails and cannot be restored on a motoring/condensing unit, the unit could be operated until the problem is corrected.

(2) The seal water pressure and flow should be checked between (site-specific) on each unit inspection.

(3) The low seal pressure alarm actuates at (site-specific).

(4) Remotely operated units at facilities that are currently unmanned should be immediately shut down.

(5) If the seal water fails on a generating unit that requires constant seal water and cannot be restored, the unit should be shut down until the problem can be corrected.

w. Failure of Turbine/Generator Bearing Oil Pumps.

NOTE: The DC oil pump is a backup to the AC oil pump. The DC pump provides a continuous supply of oil to the turbine/generator bearings in case the AC pump or station service fails.

In some cases, it may be acceptable to operate the unit with the DC oil pump for short periods of time. However, the unit will not have a backup oil supply. Consideration should be given (especially at remote facilities) to shutting down the unit and starting an alternate unit.

---

(1) The DC pump starts on a low pressure of (site-specific).

(2) If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.

(3) Remotely operated units at facilities that are currently unmanned should be immediately shut down.

(4) When any abnormal condition occurs in the turbine/generator bearing oil system, the Operator should first determine if the bearing is receiving adequate lubrication. If it is not, the unit should be unloaded and shut down immediately.

(5) When the bearing oil alarm is energized, the Operator should:

(a) Check that the bearing oil supply pressure is greater than (site-specific).

(b) Check that turbine/generator bearing temperatures are less than (site-specific).

(c) Check the AC oil pump status. If the pump is not operating, check the AC pump supply breaker.

(d) Verify operation of the DC pump (site-specific).

(e) Check for oil leaks in the system that may be causing a low pressure.

(6) If the cause of the AC pump failure is not found and corrected and the DC oil pump is not supplying proper pressure and flow, the unit should be unloaded and shut down until the condition can be corrected.

(7) For a failure of the thrust bearing oil pump:

(a) Ensure that the brakes come on and the unit is shut down quickly.

(b) At slow speeds, the thrust bearing may not have an adequate oil film.

(c) Do not restart the unit until the thrust bearing pump is repaired.

x. Loss of Permanent Magnet Generator (PMG)/Speed Signal Generator (SSG).

(1) When a loss of a PMG occurs, the unit will go to gate limit setting, and you will have no speed indication on the unit.

(2) If the SSG fails and a generator field is not present, the speed signal will be lost, and a main unit lockout and shutdown will occur. The SSG is a backup to the generator potential transformer (PT) speed signal.

(3) SSG and/or PT feeds speed information to electronic governors to operate speed switches (brake application, thrust pump application, etc.) and speed indicating meters.

(4) If local plant Operators are available, the following actions need to be taken based on the governor type (site-specific):

(a) Take the brakes off automatic (auto) to prevent brake damage.

(b) Lower the gate limit to unload the generator and achieve the no-load speed condition.

(c) Manually start thrust bearing oil pump.

(d) When the generator load is at minimum, open the generator breaker and shut down the unit.

CAUTION: Do not shut down the unit without placing brakes in manual. Failure to do so will damage the brakes.

---

(5) If the governor is a digital governor, the unit will lock out. Depending on how the governor failed, the brakes may actuate, and the thrust bearing pump may not start.

(6) For electronic or mechanical governors, lower the gate limit to unload the generator.

(7) When generator reaches (site-specific) revolutions per minute (rpm), manually apply the brakes.

y. Abnormal Operation of Governor.

NOTE: Hunting or surging could be an indication of a serious problem in the governor.

---

(1) The most common abnormal conditions affecting governors are lack of sensitivity and hunting or surging. The Operator usually will not be able to correct either of these conditions.

(2) For governor control problems, the unit should be taken off AGC. If this fails to correct the problem, the governor should be block loaded and the unit shut down as soon as possible.

(3) If the speed-adjusting motor fails to operate from the control room, the Operator may be able to control the unit from SCADA using the gate limit. Additionally, the speed adjustment may be operated temporarily at the governor, but load changes should be kept to a minimum.

(4) A loss of control power to the governor most likely will cause a unit shutdown or, at least, wicket gate closure.

(5) Operation of a unit governor in the "auxiliary" valve mode is normally done during maintenance. When the auxiliary valve is being used during an emergency, there are several things to remember:

(a) The unit transfer switch may have to be turned to "manual" to prevent the automatic operation of the gate limit motor.

(b) Turbine speed is under the complete control of the gate limit control knob.

(c) There is no speed sensing by the governor, and the servomotor timing will be slower.

(d) The governor should never be left unattended. The automatic shutdown devices are inoperative and will not shut down the generator in an emergency.

z. Loss of the Restoring Cable (Mechanical Governor).

(1) If the restoring cable breaks between the gate servomotor and the sheaves, perform the following:

(a) If the generator is online, the indications of a broken restoring cable should be like this:

- The gate position indicator is at full open.
- The unit will be motoring when the gate position indicates it should be producing power.

(b) Open the Unit Breaker under a small motoring load and take the unit offline to repair.

(c) If the generator is offline or operating isolated, the gate position indicator again will show full open, but the gates will close and shut down the unit.

(2) If the restoring cable breaks between the sheaves and the restoring cable weight, what do you look for and what should you do?

(a) Regardless of whether the wicket gates are going open or closed during a load change, the generator will operate at maximum load with the gates full open, but the gate position indicator stays at the previous load setting.

(b) The Operator should use the gate limit control knob to shut down the generator.

CAUTION: Under no circumstances should the unit be tripped if it is online. Tripping a unit with no restoring cable and the wicket gates full open will result in a runaway generator.

(3) If the pilot valve sticks in the open position and the gate limit control will not push down the pilot valve, what can you do to stop the unit?

(a) The Operator should shut off oil pressure to the pilot valve, allowing the valve servomotor plunger to fall of its own weight. This will open oil flow to the closing side of the servomotor and close the wicket gates.

CAUTION: Under no circumstances should the unit be tripped if it is online. Tripping a unit with the pilot valve stuck in the open position will result in a runaway generator.

aa. Loss of Gate Position Indication (Digital Governor).

(1) A failure of the gate positioning indicating device will cause a governor shutdown.

(2) The unit will receive a lockout.

(3) Verify that the unit is shutting down and the Unit Breaker is open.

bb. Low Governor Oil Pressure Alarm and Shutdown Relay Operation.

(1) If the low oil pressure alarm is energized, the control room Operator should stop any load changes on the unit. If the governor is hunting, block the gates with the gate limit.

(2) If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.

(3) If the alarm does not clear and the plant is unmanned, the Operator should shut down the unit.

(4) If personnel are available, check that the governor oil pumps are running with proper discharge pressure (site-specific), check the oil level in the pressure tank (site-specific), and check that the governor sump level is normal (site-specific).

(5) Check the starting and stopping pressures of both pumps (site-specific).

(6) If there is trouble with the lead pump, the lag pump should be put on lead. If there is complete failure of both pumps, the unit must be shut down.

(7) If the low oil pressure shutdown relay operates, the unit will be automatically shut down and must be left down until the cause of the low oil pressure is found and corrected. This may cause penstock gate closure.

cc. Overspeed or Runaway.

(1) There are two types of actuations for overspeed: instantaneous and sustained. The overspeed alarm and shutdown relay are set to operate at (site-specific speed and time).

(2) If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.

(3) The Operator should monitor the unit RPM to ensure that the governor is taking control of the unit or that the unit is shutting down.

(4) If an overspeed shutdown occurs, the entire governor system should be inspected before restarting the unit.

(5) If the governor is acting abnormally, DO NOT open the generator breaker until the generator load is zeroed, using the gate limit.

(6) In case of a runaway condition where the wicket gates fail to close, the Operator should close the penstock gate.

dd. Turbine Pit High Water.

(1) A turbine pit high water alarm actuates at (site-specific). A turbine pit high water alarm could be caused by the following:

(a) Head cover seal failure.

(b) Cooling water line failure.

(c) Turbine packing failure.

(d) Plugged drain lines.

(e) Head cover pump failure.

(f) Wicket gate seal failure.

(2) Remotely operated units, whose facility also currently is unmanned, should be immediately shut down.

(3) The high-level alarm should be investigated to determine the cause of the high water alarm.

(4) The unit operation may continue if the leak can be isolated or if the leak is small and can be repaired during a scheduled outage.

(5) For large leaks, the unit should be unloaded, shut down, and the penstock gate closed until the condition can be corrected. If the leak is below the tail race water elevation, the tail race stop logs may have to be installed also.

ee. Failure of Gate Shear Pin.

(1) For a load rejection with shear pin failure, close the penstock gate.

(2) The wicket gate operating linkage for each gate is provided with a safety shear pin to prevent damage to gates in case they are blocked by foreign material getting between them. While shear pins usually fail when the gates are closed with foreign material between them, they also occasionally fail when the unit is on load.

(3) When a shear pin fails, the Operator may notice unusual noise and vibration of the turbine or elevated turbine bearing temperatures, especially while the gate is closing.

(4) Operators should be alert for this and should check for broken shear pins when the turbine is unusually noisy. If a broken shear pin is found, the unit should be unloaded, if possible, and operated at minimum load until the broken shear pin can be replaced.

ff. Unusual Mechanical Noise or Vibration.

(1) Plant staff should investigate any unusual mechanical noise or vibration. Check shaft runout and generator/turbine bearing temperatures. Inspect for broken shear pins or for foreign material lodged in the gates or wheel.

(2) If the abnormal condition is such that continued operation of the unit might do further damage or if there is evidence of foreign material in the gates or wheel, shut down the unit immediately.

(3) If severe vibration and noise develops, shut down the unit immediately.

gg. Transformer Differential Relay Operation.

(1) When the transformer differential relay operates, the Operator should ensure that the associated generator and switchyard breakers are open.

CAUTION: Do not de-energize transformer oil pumps of operating transformers.

(2) Stop the transformer oil pumps (site-specific).

(3) If fire is present at the transformer, ensure that the transformer deluge system is activated (site-specific).

(4) If no fire is present, ensure that the transformer deluge system is not operating.

(5) If a fire has occurred, initiate the Prefire Plan.

(6) Ensure that the associated generators are shut down.

(7) Do not restart units until the cause of the relay action has been investigated and corrected.

hh. Transformer High Temperature Alarm or Shutdown Relay Operation.

(1) Transformers usually have cooling oil circulating pumps with fans and/or heat exchangers for removing heat. The high temperature alarm actuates at (site-specific).

(2) If the alarm does not clear and the plant is unmanned, the Operator should unload the transformer.

(3) The Operator should perform the following:

(a) Ensure transformer loading is within the limits (site-specific).

(b) Ensure both oil pumps are operating.

(c) Check that the transformer oil level is normal (site-specific).

(d) Check that the cooling water pressure or flow is normal (site-specific). If they are not normal, check the cooling water supply valves and strainer.

(e) Check that the cooling fans are operating (site-specific).

(4) If the transformer temperature continues to rise, it may be necessary to unload the transformer.

ii. Transformer Oil Flow Failure.

(1) Each transformer is provided with two oil pumps that circulate the oil through water-cooled heat exchangers for cooling purposes. A continuous flow of oil is, therefore, necessary to provide adequate cooling.

(2) If the alarm does not clear and the plant is unmanned, the Operator should unload the transformer.

(3) Each pump is provided with a no-flow/low-flow device that energizes the Transformer Oil Flow alarm. This may start a timer that will de-energize the transformer in (site-specific).

(4) When transformer oil flow failure is indicated by the alarm, Operators should take the following actions:

(a) Check the transformer temperatures.

(b) Check the operation of oil pumps.

(c) Check the oil supply valves to make certain they are 100% open.

(d) Check the oil pump power supply circuits for tripped breakers or overloads.

(5) Although transformers can be operated for some time without oil circulation, remember that the winding temperature detectors may not read correctly (local temperature indication) when there is no oil flow. The actual temperatures are likely to be higher than indicated on the recorder, and transformers carrying rated generator load should not be operated with no oil circulation at temperatures above (site-specific).

(6) The hot spot detector (site-specific) is a better choice for monitoring transformer temperature. The transformer temperature is obtained from embedded resistance temperature detector (RTD) and current/load on the transformer, and this is the one usually fed to the recorder/SCADA.

(7) If normal oil flow cannot be restored, the associated units should be unloaded, shut down, and the transformers should then be de-energized.

jj. Sudden Pressure Relay.

(1) The operation of a sudden pressure relay is an indication of a large internal fault in the transformer.

(2) When the sudden pressure relay operates, it should trip the transformer lockout relay, and the Operator should take the following actions:

(a) Ensure the associated generator and switch yard breakers are open.

(b) Ensure the lockout tripped and properly operated by verifying appropriate circuit breakers opened, fire water deluge system activated, etc. (site-specific).

CAUTION: Do not de-energize the transformer oil pumps on operating transformers.

(3) Stop the transformer oil pumps (if accessible).

(4) Check for fire at the transformer and turn on the water spray if necessary.

(5) Ensure the associated generators are shut down.

(6) Units should not be restarted until the cause of the relay action has been investigated and corrected.

kk. Transformer Oil and Gas Alarm.

(1) The transformer oil and gas alarm will be energized by any of the following abnormal conditions:

(a) Low oil level.

(b) Low cylinder gas pressure.

(c) High or low transformer gas pressure.

(d) Relief valve failure.

(2) When the alarm is energized, the Operator first should try to determine which abnormal condition caused the alarm.

(3) If the oil level gauge indicates low oil level, the Operator should check for oil leakage at the following:

(a) Transformers.

(b) Heat exchangers.

(c) Connecting piping.

(4) Low Cylinder Gas Pressure is energized at (site-specific) and indicates that it is time to replace the nitrogen cylinder with a new one. The cylinder normally can be left until maintenance personnel can replace it.

(5) The nitrogen gas pressure in the transformer is self-regulating in that gas is added from the cylinder when the pressure is too low (site-specific) and is vented to the atmosphere by a pressure relief valve when the pressure gets too high (site-specific).

(6) If the pressure is low, the Operator should check that the gauge is reading correctly and that the automatic regulating system is functioning to add gas to the transformer.

(7) If the pressure is high, check that the relief valve is operating. If it is not, slowly open the sampling or vent valve to release enough gas to clear the alarm.

ll. Low Oil Pressure/Level for Transformers with Conservator Tank.

(1) Some transformers are equipped with a constant oil pressure system. The system consists of a conservator tank, a urethane or rubber bladder, a pressure-vacuum bleeder and gauge, and an oil level indicator.

(2) As oil expands and contracts following loading levels and ambient temperature, the bladder expels air to the atmosphere or allows air into the bladder from the atmosphere. These systems are designed to regulate the reservoir pressure between (site-specific) and will alarm outside those settings.

(3) Check the pressure gauge for an accurate reading.

(a) Check the oil level indicator. If the bladder is damaged or ruptured, a low indication should be present, but the conservator tank will still be functional. Some conservator tanks have a bladder failure relay (site-specific).

(b) Check for oil leaks at the main tank, conservator, and piping.

(c) Monitor transformer temperatures and loading until such time that the transformer can be removed from service for repair.

Appendix B
Preventive Maintenance Standard Tasks

Time periods within the preventive maintenance tasks correspond to the following: Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P) (Periodic indicated in years).

Table B-1
Air Systems Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR AIR SYSTEMS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-AS-001	Check operation of gauge	X					
HMS-AS-002	Drain condensation from bottom of reservoirs/accumulator tanks.		X				
HMS-AS-003	Check operation/calibration of pressure/temperature switches.					X	
HMS-AS-004	Verify compressor starts unloaded.		X				
HMS-AS-005	Check oil pressure & level.		X				
HMS-AS-006	Clean or replace air intake filter element.			X			
HMS-AS-007	Check belts/chains for tension, wear, and aging.			X			
HMS-AS-008	Check pulley clamp bolts & screws for tightness.			X			
HMS-AS-009	Record hour meter reading			X			
HMS-AS-010	Inspect compressor components for corrosion & fatigue.					X	
HMS-AS-011	Check shaft couplings for excessive runout or vibration.					X	
HMS-AS-012	Check flow of water or coolant through compressor and aftercooler. Flush as required		X				
HMS-AS-013	Thoroughly clean cooling fins of air-cooled compressors and radiators of water-cooled compressors.					X	
HMS-AS-014	Replace oil filter as required			X			
HMS-AS-015	Check piping for corrosion.					X	
HMS-AS-016	Inspect reed valves for condition and correct operation					X	
HMS-AS-017	Clean control cabinets and devices.					X	
HMS-AS-018	Inspect wiring and connections					X	
HMS-AS-019	Check controls for proper operation.					X	
HMS-AS-020	Lubricate motor bearings					X	
HMS-AS-021	Check crankcase heaters for correct operation					X	
HMS-AS-022	Check motor insulation resistance					X	
HMS-AS-023	Clean motor cooling fins					X	
HMS-AS-024	Perform visual inspection of starters/contactors					X	
HMS-AS-025	Measure motor full load amps					X	
HMS-AS-026	Infrared scan motor.					X	
HMS-AS-027	Check calibration of transducers					X	

PREVENTIVE MAINTENANCE TASKS FOR AIR SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-AS-028	Check operation of pressure relief valves					X	
HMS-AS-029	Check calibration of pressure relief valves					X	
HMS-AS-030	Check operation of dryers.		X				
	PRESSURE VESSELS						
HMS-AS-031	Drain condensate from air receivers.	X					
HMS-AS-032	Inspect receiver tanks.						5
HMS-AS-033	Check operation of pressure relief valves					X	
HMS-AS-034	Check calibration of pressure relief valves						5
	PIPING						
HMS-AS-035	Check regulating valves for correct pressure					X	
HMS-AS-036	Exercise isolation valves					X	
HMS-AS-037	Check air distribution system for air leaks.			X			
HMS-AS-038	Check automatic traps for leaks and proper operation.					X	
HMS-AS-039	Clean strainer and check for corrosion or scale buildup.		X				
HMS-AS-040	Check pipe hangers and brackets					X	
HMS-AS-041	Check operation of gauges.	X					
HMS-AS-042	Drain condensation from traps.		X				
HMS-AS-043	Calibrate guages and transducers.					X	

Table B-2
Breaker Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR BREAKERS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-BR-001	Infrared Scan in normal operating conditions prior to removal from service and in normal operating condition after return to service.					X	
HMS-BR-002	Clean insulating components.					X	
HMS-BR-003	Record normal operating loads (if equipped with meters)		X				
HMS-BR-004	Review Equipment ratings; Current interrupting rating vs. short circuit current analysis; installed vs. drawings; Equip rating vs. Facility Rating (NERC FAC-008-3)					X	
HMS-BR-005	Visual inspection (contact wear, foundation, grounds, paint, cracks, leaks, cable terminations, stress cones, evidence of leaks, evidence of tracking, cleanliness, all equipment and connections are in normal operating positions)					X	
HMS-BR-006	Mechanical inspection of external screws, bolts, electrical terminals.					X	
HMS-BR-007	Operate breaker.				X		
HMS-BR-008	Verify correct operation of auxiliary features such as trip and pickup indicators					X	
HMS-BR-009	Perform fault load studies and recalculate settings.						5
HMS-BR-010	Retorque line side of feeder breakers						2
	LOW VOLTAGE CIRCUIT BREAKER (UNDER 600V)						
HMS-BR-011	Verify alignment of operating mechanism.					X	
HMS-BR-012	Clean and relubricate operating mechanism.					X	
HMS-BR-013	Record Number of Operations					X	
HMS-BR-014	Perform Contact Resistance Test						2
HMS-BR-015	Perform overcurrent fault trip testing and verify settings.						2
HMS-BR-016	Perform Insulation Resistance Test.						2
HMS-BR-017	Check cabinet heaters for proper operation.	X					
HMS-BR-018	Clean Unit (Insulating parts, including bushings, should be wiped clean.)					X	
HMS-BR-019	Inspect arc chutes.					X	
HMS-BR-020	Functional test control circuits & interlocks						2
HMS-BR-021	Inspect contract alignment against manufacturer's recommendations.						2
HMS-BR-022	Perform visual inspection of removable trip unit					X	
HMS-BR-023	Perform Rated Hold-In Test						2
HMS-BR-024	Perform Shunt Trip Release Test						2
HMS-BR-025	Perform Under-Voltage Trip Release Tests						2
HMS-BR-026	Determine long-time pickup and delay by primary current injection.						2
HMS-BR-027	Determine short-time pickup and delay by primary current injection.						2
HMS-BR-028	Determine ground-fault pickup delay by primary current injection.						2
HMS-BR-029	Determine instantaneous pickup current by primary injection.						2
HMS-BR-030	Perform minimum pickup voltage test on shunt trip and close coils						2

PREVENTIVE MAINTENANCE TASKS FOR BREAKERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	AIR CIRCUIT BREAKERS						
HMS-BR-031	Verify lubrication and alignment of operating mechanism.					X	
HMS-BR-032	Record Number of Operations					X	
HMS-BR-033	Perform Contact Resistance Test						2
HMS-BR-034	Perform Motion analysis / Timing Test						2
HMS-BR-035	Perform overcurrent fault trip testing and verify settings.						2
HMS-BR-036	Perform Insulation Resistance Test.						2
HMS-BR-037	Check cabinet heaters for proper operation.			X			
HMS-BR-038	Clean Unit (Insulating parts, including bushings, should be wiped clean.)					X	
HMS-BR-039	Inspect Interrupter					X	
HMS-BR-040	Functional test control circuits & interlocks					X	
HMS-BR-041	Inspect arc chutes.						2
HMS-BR-042	Inspect puffer operation.						2
HMS-BR-043	Inspect air system.					X	
	VACUUM CIRCUIT BREAKERS						
HMS-BR-044	Verify lubrication and alignment of operating mechanism.					X	
HMS-BR-045	Record Number of Operations					X	
HMS-BR-046	Perform Contact Resistance Test					X	
HMS-BR-047	Perform Motion analysis / Timing Test						2
HMS-BR-048	Perform overcurrent fault trip testing and verify settings.						2
HMS-BR-049	Perform Insulation Resistance Test.						2
HMS-BR-050	Check cabinet heaters for proper operation.			X			
HMS-BR-051	Functional test control circuits & interlocks					X	
HMS-BR-052	Measure change in shaft position.					X	
HMS-BR-053	Perform vacuum integrity test						2
	OIL CIRCUIT BREAKERS						
HMS-BR-054	Verify alignment of operating mechanism.						4
HMS-BR-055	Record Number of Operations					X	
HMS-BR-056	Perform Contact Resistance Test						2
HMS-BR-057	Perform Motion analysis / Timing Test						2
HMS-BR-058	Perform overcurrent fault trip testing and verify settings.						2
HMS-BR-059	Perform Insulation Resistance Test.						2
HMS-BR-060	Check cabinet heaters for proper operation.			X			
HMS-BR-061	Clean and relubricate operating mechanism.		X				

PREVENTIVE MAINTENANCE TASKS FOR BREAKERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-BR-062	Functional test control circuits & interlocks					X	
HMS-BR-063	Clean tank and all other components in contact with oil.						4
HMS-BR-064	Test dielectric condition of oil and visually inspect for excessive carbon build up.					X	
HMS-BR-065	Inspect and service hydraulic or pneumatic system and/or air compressor.					X	
	SF6 GAS CIRCUIT BREAKERS						
HMS-BR-066	Verify lubrication and alignment of operating mechanism.						4
HMS-BR-067	Record Number of Operations					X	
HMS-BR-068	Perform Contact Resistance Test						2
HMS-BR-069	Perform Motion analysis / Timing Test						2
HMS-BR-070	Perform overcurrent fault trip testing and verify settings.						2
HMS-BR-071	Perform Insulation Resistance Test.						2
HMS-BR-072	Check cabinet heaters for proper operation.			X			
HMS-BR-073	Clean Unit (Insulating parts, including bushings, should be wiped clean.)					X	
HMS-BR-074	Inspect Interrupter						2
HMS-BR-075	Functional test control circuits & interlocks					X	
HMS-BR-076	Perform Contact Resistance Test						2
HMS-BR-077	Record gas pressure and temperature; compare with tolerances and prior readings		X				
HMS-BR-078	Verify operation and calibration of temperature and pressure switches and gauges					X	
HMS-BR-079	Perform a moisture test on gas						2
HMS-BR-080	Overhaul breaker with new seals, contacts, nozzles per mfr recommendation						10
HMS-BR-081	Overhaul disconnect, grounding, and breaking switches per mfr recommendation						10
	BUSHINGS						
HMS-BR-082	Clean all exterior surfaces					X	
HMS-BR-083	Visually inspect for cracks, corrosion, and leaks					X	
HMS-BR-084	Inspect gaskets						2
HMS-BR-085	Inspect capacitance taps and test electrodes.						2
HMS-BR-086	Check oil level.					X	
HMS-BR-087	Perform Power Factor Test.						2
HMS-BR-088	Perform Capacitance Test						2

Table B-3
Bulkhead/Stoplog Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR BULKHEADS/STOPLOGS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-BH-001	Check concrete and embedded components for cracks, spalling, or signs of movement					X	
HMS-BH-002	Inspect seals and contact surfaces					X	
HMS-BH-003	Ensure proper lubrication					X	
HMS-BH-004	Inspect for cracks, corrosion, fatigue, damaged welds					X	
HMS-BH-005	Operate gate or valve through a complete open-close cycle under balanced conditions					X	
HMS-BH-006	Visually inspect all threaded, welded, and flanged fittings, checking for any leaks or corrosion					X	
HMS-BH-007	Check condition of cathodic protection					X	
	BULKHEADS/STOGLOGS						
HMS-BH-008	Inspect condition of lifting beam					X	
HMS-BH-009	Inspect guides					X	
HMS-BH-010	Inspect springs and spring pockets					X	
HMS-BH-011	Inspect alignment devices					X	
HMS-BH-012	Inspect rollers					X	
HMS-BH-013	Inspect lifting beam attachment point					X	
	TRASH RACKS						
HMS-BH-014	Clean debris from trash rack					X	
HMS-BH-015	Verify calibration and operation of head differential pressure transducer					X	
HMS-BH-016	Inspect debris removal systems					X	
	GATES						
HMS-BH-017	Inspect roller chain assemblies					X	
HMS-BH-018	Inspect guide rollers					X	
HMS-BH-019	Inspect lifting beam attachment point					X	
	OPERATING MACHINERY						
HMS-BH-020	Visually inspect each motor					X	
HMS-BH-021	Check all electrical connections.					X	
HMS-BH-022	Verify proper lubrication.					X	
HMS-BH-023	Measure motor insulation resistance					X	

PREVENTIVE MAINTENANCE TASKS FOR BULKHEADS/STOPLOGS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-BH-024	Measure motor full load amps					X	
HMS-BH-025	Perform infrared scan					X	
HMS-BH-026	Inspect ropes, chains, and cables					X	
HMS-BH-027	Inspect gearboxes					X	
HMS-BH-028	Inspect hydraulic system for leaks					X	
HMS-BH-029	Inspect filter.					X	
HMS-BH-030	Perform oil analysis.					X	
HMS-BH-031	Verify calibration of gauges, switches, indicators and pressure relief devices.						3
HMS-BH-032	Inspect control and annunciation circuits					X	
HMS-BH-033	Inspect hoist brake circuit					X	
HMS-BH-034	Inspect brake drums and pads					X	
HMS-BH-035	Inspect sheaves and drums					X	
HMS-BH-036	Inspect drive machinery					X	

Table B-4
Buswork Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR BUSWORK

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-BW-001	Infrared Scan in normal operating conditions prior to removal from service and in normal operating conditionafter return to service.					X	
HMS-BW-002	Review Equipment ratings; Current interrupting rating vs. short circuit current analysis; installed vs. drawings; Equiprating vs. Facility Rating (NERC FAC-008-3)					X	
HMS-BW-003	Visual Inspection (examine bus assemblies for good condition, check connections for signs of overheating, foundation, grounds, paint, cracks, leaks, cable terminations, stress cones, evidence of leaks, evidence of tracking, cleanliness, all equipment and connections are innormal operating positions)					X	
HMS-BW-004	Mechanical Inspection (Check expansion joints or flexible connections for good condition, verify bolted connections, check integrity of electrical connections)					X	
HMS-BW-005	Measure & Record the resistance of the station grounding system.					X	
HMS-BW-006	[Insulation test] (Hipot or Doble test – power frequency dielectric loss, dc insulation resistance, power factor)						4
HMS-BW-007	Clean enclosures					X	
HMS-BW-008	Verify operation of busway space heaters	X					
	INSULATORS						
HMS-BW-009	Inspect for damage, overheating, or tracking.					X	
HMS-BW-010	Clean insulators					X	
HMS-BW-011	Insulator - dielectric loss test						4
	BUSHINGS						
HMS-BW-012	Visual Inspection (examine connections for signs of overheating, paint, cracks, leaks, cable terminations, stress cones, evidence of leaks, evidence of tracking, cleanliness, and all equipment and connections are in normal operating positions)					X	
HMS-BW-013	Clean bushings					X	
HMS-BW-014	Check oil level as applicable		X				
HMS-BW-015	Bushings – Insulation test (Doble test – power frequency dielectric loss, dc insulation resistance, power factor)						4
	LIGHTNING ARRESTORS						
HMS-BW-016	Inspect physical and mechanical condition (anchorage, alignment, and grounding.)					X	
HMS-BW-017	Clean the unit.					X	
HMS-BW-018	Test grounding connection					X	

PREVENTIVE MAINTENANCE TASKS FOR BUSWORK

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-BW-019	Verify that stroke counter, if present, is correctly mounted and electrically connected.		X				
HMS-BW-020	Perform insulation resistance, watts-loss or leakage current test.						4
	MEDIUM/HIGH VOLTAGE POWER CABLE BUS						
HMS-BW-021	Insulation test (DC ramp test, PF Tip-up test, AC-hipot, DC-hipot, Very Low Frequency (VLF) hipot, Doble PF, partial discharge)						4
HMS-BW-022	Check insulating oil as applicable– dissolved gas analysis (DGA), physical, and chemical tests					X	
	FORCED-AIR COOLED BUS						
HMS-BW-023	Verify Fan rotation and speed		X				
HMS-BW-024	Check fan and motor vibration		X				
HMS-BW-025	Measure and Record Motor operating voltage and load current		X				
HMS-BW-026	Measure and Record heat exchanger coolant flow rate and temperature		X				
HMS-BW-027	Verify air balance within the bus system		X				
HMS-BW-028	Confirm calibrations/settings for alarm and indicating devices (thermostats, thermometers, pressure switches,etc.)					X	
HMS-BW-029	Inspect/replace filters		X				

Table B-5
Crane Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR CRANES
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-CR-001	Perform inspection and maintenance unique to the crane manufacturer	X					
HMS-CR-002	Perform crane load test (100% rated load)						X[1]
HMS-CR-003	Check all framework for deformation, cracks, and corrosion, paying close attention to load bearing membersand welded joints.					X	
HMS-CR-004	On fixed cranes, check column anchorage and supports for deformed bolts or concrete cracks in the baseplate and foundation.					X	
HMS-CR-005	Inspect all functional operating mechanisms and their components for excessive wear or damage.		X[2]				
HMS-CR-006	Verify crane and hoist motions are smooth and regular forall speed steps, with no hesitations, vibration, binding, weaving, unusual noise, or other irregularity.		X[2]				
HMS-CR-007	Clean the crane cab, inspecting condition of seat, windows, doors, hand and foot controls, etc		X[2]				
HMS-CR-008	Inspect the fire extinguisher in the crane cab.		X[2]				
HMS-CR-009	Verify the crane operation and maintenance log book is being used properly		X[2]				
HMS-CR-010	With crane in motion, check for abnormal vibration or skewing in the crane support structure, bracing, and cranerails.		X[2]				
HMS-CR-011	Check condition of handrails and ladders		X[2]				
HMS-CR-012	Check ladder rungs and stairs for significant wear of antislip surfaces.		X[2]				
HMS-CR-013	Check that footwalks and toeboards are secure and in good condition		X[2]				
HMS-CR-014	Inspect stops and bumpers for wear, cracks, corrosion, or distortion.					X	
HMS-CR-015	Check for leaking of hydraulic bumpers and fill to proper level.					X	
HMS-CR-016	Check rubber or plastic bumpers for cracks or other damage.					X	
HMS-CR-017	Verify that all guards are in place and securely fastened.		X[2]				
	CRANE RAILS						
HMS-CR-018	Check rails for alignment and level. Look for dips,cleanness, grease, or oil.					X	
HMS-CR-019	Inspect crane rail clips or welds for damage.					X	
HMS-CR-020	Check crane rail expansion gaps for uniformity and conformance with spacing tolerances.					X	
HMS-CR-021	Inspect for wear on the crane rails, both on the top and side of the rail head.					X	
HMS-CR-022	Clean crane rails as needed			X			
HMS-CR-023	Check concrete crane rail supports for cracking or spalling					X	
HMS-CR-024	Check steel crane rail supports for corrosion and loose bolts or rivets.					X	
HMS-CR-025	Inspect crane rail stops					X	
HMS-CR-026	Inspect and adjust rail sweeps					X	
	CONTROL SYSTEM						
HMS-CR-027	Verify function of the general crane control systems and components thereof		X[2]				
HMS-CR-028	Verify function and adjustment of the lower-limit switch (as applicable) and verify that at least two full wraps of wire rope remain on the drum at the lower limit.		X[2]				

PREVENTIVE MAINTENANCE TASKS FOR CRANES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-CR-029	Verify function and adjustment of the upper-limit switch and verify proper wire rope spooling on drum.		X[2]				
HMS-CR-030	Check function of brake control circuits for bridge, trolley, main & auxiliary hoist		X[2]				
HMS-CR-031	Check for proper operation of all electrical safety devices including emergency stop switches.		X[2]				
HMS-CR-032	Check all lights for proper operation.		X[2]				
HMS-CR-033	Inspect to verify that all wiring and connections are in good condition					X	
HMS-CR-034	Ensure that required control labels as present and are legible					X	
HMS-CR-035	Inspect contactor contacts for signs of deterioration and overheating					X	
HMS-CR-036	Inspect levers and cams, ensure adequate lubrication					X	
HMS-CR-037	Visually examine resistor tubes for cracks, loose bands and connections, and broken resistance wire.					X	
HMS-CR-038	Clean resistor banks if dirty.					X	
	ROPE, DRUMS, SHEAVES, HOOKS, LOAD CHAIN						
HMS-CR-039	With a sheave gauge, check grooves of drums and sheaves for wear					X	
HMS-CR-040	Inspect load block guards for contact with sheaves or wire rope					X	
HMS-CR-041	Inspect wire rope dead-ends.					X	
HMS-CR-042	Inspect the end connections.					X	
HMS-CR-043	Visually inspect hoisting rope or chain for damage, wear, and proper lubrication.		X[2]				
HMS-CR-044	Visually inspect hoist rope or chain for proper reeving and spooling		X[2]				
HMS-CR-045	Run-out the rope or chain to visually examine those portions that flex over sheaves, sprockets, and other areassubject to wear or abrasion.					X	
HMS-CR-046	Inspect wire ropes		X[2]				
HMS-CR-047	Clean and lubricate wire rope, sheaves and drums					X	
HMS-CR-048	Verify hoist chain feeds smoothly into and away from sprockets.		X[2]				
HMS-CR-049	Inspect hooks for wear, cracking, corrosion and deformation.		X[2]				
HMS-CR-050	Verify function of hook latches		X[2]				
HMS-CR-051	Verify that swivel hooks are free to rotate		X[2]				
HMS-CR-052	Lubricate swivel and sheave bearings as required.					X	
	BRAKES						
HMS-CR-053	Ensure that brakes are functioning normally and that there is no slippage, excessive play, or binding.		X[2]				
HMS-CR-054	Check operation of drive system, bridge and trolley brakes and look for leaks in hydraulic lines		X[2]				
HMS-CR-055	Clean dust and dirt from brakes					X	
HMS-CR-056	Check brake lining for excessive wear and oil contamination. Inspect for signs of heating.		X[2]				
HMS-CR-057	Measure and record break shoe clearance and thickness.					X	
HMS-CR-058	Adjust brake shoe clearance					X	

PREVENTIVE MAINTENANCE TASKS FOR CRANES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-CR-059	Check brake drums for scoring and wear					X	
HMS-CR-060	Lightly lubricate brake pivot points					X	
HMS-CR-061	Inspect brake fluid level		X				
	GEARBOXES, DRIVE SYSTEMS						
HMS-CR-062	Check mounted bearings for tightness, wear, and proper lubrication.					X	
HMS-CR-063	Listen for abnormal noise in gear boxes and motors		X[2]				
HMS-CR-064	Inspect oil and gear boxes for metal and nonmetallic particles.					X	
HMS-CR-065	Check oil seals for leaks					X	
HMS-CR-066	Inspect gears for missing or worn teeth, abnormal wearpatterns and excessive heat					X	
HMS-CR-067	Ensure proper lubrication of gearboxes, bearings, etc					X	
HMS-CR-068	Inspect condition of shafts and couplings					X	
HMS-CR-069	Inspect condition of all protective guards					X	
HMS-CR-070	Check that drive chain feeds into and away from sprockets smoothly		X[2]				
HMS-CR-071	Inspect drive chain for stretch, wear, corrosion, and other damage		X[2]				
HMS-CR-072	Inspect roller type drive chain under load in lifting andlowering directions, observing for smooth feed of chaininto and away from the sprockets					X	
HMS-CR-073	Inspect roller type drive chain for damage, corrosion, etc.					X[2]	
HMS-CR-074	Clean and lubricate roller type drive chain					X	
	MOTORS						
HMS-CR-075	Perform an infrared scan of the motor					X	
HMS-CR-076	Clean and inspect motor brushes for wear and slip rings for pitting					X	
HMS-CR-077	Inspect commutators for wear, flat spots, high bars, discoloration, or ridging					X	
HMS-CR-078	Check connections to brushes, verify tightness and look for signs of excessive heat					X	
HMS-CR-079	Clean motor air intake screens					X	
HMS-CR-080	Ensure motor bearings are properly lubricated					X	
	POWER SUPPLY						
HMS-CR-081	Check the contact surfaces of open conductors andcollectors for signs of arcing damage, pitting, and corrosion.					X	
HMS-CR-082	Clean insulators and check their condition					X	
HMS-CR-083	Check that festoon type conductor cable moves freely with bridge and trolley movement.					X	
HMS-CR-084	Inspect power cables and control pendants					X	

1. As determined by engineer or manufacturer.
2. Before each use, otherwise monthly.

Table B-6
DC System Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR DC SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-DC-001	Verify presence and function of safety systems		X				
HMS-DC-002	Perform visual inspection					X	
	BATTERY						
HMS-DC-003	Check for unintentional grounds & condition of battery rack		X				
HMS-DC-004	Check ventilation, temperature, & humidity control systems		X				
HMS-DC-005	Perform capacity\load test						5
HMS-DC-006	Inspect electrical connections and wiring					X	
HMS-DC-007	Check electrolyte level of each cell			X			
HMS-DC-008	Check Battery Voltage		X				
HMS-DC-009	Check Cell Voltage			X			
HMS-DC-010	Check Intercell Resistance					X	
HMS-DC-011	Check specific gravity		X				
HMS-DC-012	Check cell water level		X				
HMS-DC-013	Inspect cell posts for corrosion/continuity					X	
HMS-DC-014	Check tightness of intercell connections					X	
	BATTERY CHARGER						
HMS-DC-015	Check output voltage		X				
HMS-DC-016	Clean any accumulated dust, dirt.		X				
HMS-DC-017	Inspect electrical connections and wiring					X	
HMS-DC-018	Verify output waveform						5
HMS-DC-019	Verify function of current limiter						5
HMS-DC-020	Check for annunciation					X	
	SWITCHGEAR (SEE ALSO BREAKERS)						
HMS-DC-021	Inspect electrical connections and wiring						5
HMS-DC-022	Clean any accumulated dust, dirt.						5
	SWITCHBOARDS						
HMS-DC-023	Inspect electrical connections and wiring						5

PREVENTIVE MAINTENANCE TASKS FOR DC SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-DC-024	Clean any accumulated dust, dirt.						5
	BATTERY MONITORING SYSTEM						
HMS-DC-025	Inspect unit for indication of abnormal battery conditions	X					
HMS-DC-026	Reconcile monitoring system indicated values with manual readings			X			
HMS-DC-027	Backup monitoring system data		X				
HMS-DC-028	Clean any accumulated dust, dirt.					X	
HMS-DC-029	Inspect electrical connections and wiring					X	
	INVERTER						
HMS-DC-030	Check input\output voltages						5
HMS-DC-031	Check system load						5
HMS-DC-032	Inspect electrical connections and wiring					X	
HMS-DC-033	Clean any accumulated dust, dirt.					X	
	CONTROL CIRCUITS						
HMS-DC-034	Inspect electrical connections and wiring						5
HMS-DC-035	Function test protection circuits						5

Table B-7
Diesel Generator Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR DIESEL GENERATORS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-DG-001	Check engine oil level; add as required		X				
HMS-DG-002	Check battery charge and electrolyte specific gravity; add water as required. Check terminals for corrosion; clean as required		X				
HMS-DG-003	Check belts for wear and proper tension; adjust as necessary		X				
HMS-DG-004	Check that crank case heater is operating		X				
HMS-DG-005	Check wiring, connections, switches, etc.; adjust as required		X				
HMS-DG-006	Perform 30 minute generator test run; check for proper operation		X				
HMS-DG-007	Check fuel level with gage pole, add as required		X				
HMS-DG-008	Wipe dust and dirt from engine and generator		X				
HMS-DG-009	Clean area around generator		X				
HMS-DG-010	Change engine oil and oil filter					X	
HMS-DG-011	Check engine air filter; change as required					X	
HMS-DG-012	Check injector nozzle condition; service or replace as required						5
HMS-DG-013	Check engine coolant level and radiator system		X				
HMS-DG-014	Clean crankcase breather				X		
HMS-DG-015	Examine Radiator Hoses				X		
HMS-DG-016	Flush cooling system, replace filter					X	
HMS-DG-017	Perform load test			X			
HMS-DG-018	Check engine valve clearance						5
HMS-DG-019	Inspect fuel tank and filters					X	
HMS-DG-020	Clean fuel tank						10

Table B-8
Disconnect Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR DISCONNECTS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-DN-001	Inspect insulators.					x	
HMS-DN-002	Inspect connections.					x	
HMS-DN-003	Verify proper seating and alignment.					x	
HMS-DN-004	Check simultaneous closing of all blades.					x	
HMS-DN-005	Clean insulators.					x	
HMS-DN-006	Insulator power factor test					x	
HMS-DN-007	Manually operate.					x	
HMS-DN-008	Infrared scan.					x	
HMS-DN-009	Verify full travel.					x	
HMS-DN-010	Inspect interphase linkages.					x	
HMS-DN-011	Check gearboxes for moisture.					x	
HMS-DN-012	Verify grounding connections of platform and operating handle.			x			
HMS-DN-013	Inspect bolts, nuts, washers, cotter pins, and terminal connectors.					x	
HMS-DN-014	Inspect arcing horn.					x	
HMS-DN-015	Visually inspect contact points.					x	
HMS-DN-016	Inspect enclosure (as applicable)					x	
	LOAD BREAK DISCONNECTS						
HMS-DN-017	Inspect arc chutes					x	
HMS-DN-018	Check arcing fingers and blades					x	
HMS-DN-019	Operate manually and verify opening and closing alignment					x	
HMS-DN-020	Lubricate moving parts					x	
HMS-DN-021	Inspect bolts, nuts, washers, cotter pins, and terminal connectors.			x			
HMS-DN-022	Check gears for damage			x			
HMS-DN-023	Clean bearings					x	
HMS-DN-024	Check simultaneous closing of all blades.					x	
	CIRCUIT SWITCHERS						
HMS-DN-025	Check interrupter operation					x	

PREVENTIVE MAINTENANCE TASKS FOR DISCONNECTS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-DN-026	Check and adjust switcher linkages					x	
HMS-DN-027	Check proper operation and adjustment of limit switches					x	
HMS-DN-028	Lubricate gears					x	
HMS-DN-029	Check gearmotor					x	
HMS-DN-030	Inspect for oil leaks					x	
	MOTOR OPERATORS						
HMS-DN-031	Check condition of enclosure					x	
HMS-DN-032	Check for moisture					x	
HMS-DN-033	Check proper operation of space heaters					x	
HMS-DN-034	Check fuses and fuse clips					x	
HMS-DN-035	Verify proper operation and adjustment of limit switches					x	
HMS-DN-036	Manually operate.					x	
HMS-DN-037	Lubricate gears					x	

Table B-9
Exciter Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR EXCITERS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-EX-001	Inspect cabinet air filters and replace as necessary.		X				
HMS-EX-002	Infrared Scan					X	
HMS-EX-003	Examine operating and control mechanism for proper condition. Observe for proper operation when unit is on regulator control.					X	
HMS-EX-004	See that indicating lights, dampening elements, transfer switches and adjusting rheostats are in condition to insure good operation.					X	
HMS-EX-005	Repair, replace and adjust components as prescribed in the manufacturer's instructions to provide good operation.					X	
HMS-EX-006	Swap from Auto to Manual and verify seamless transfer					X	
HMS-EX-007	Drive VARs to over and under excitation limits and verify operation of limiter					X	
HMS-EX-008	Check power system stabilizer in proper operation mode	X					
HMS-EX-009	Check and calibrate meters						See Meters
HMS-EX-010	Exciter overcurrent relay testing						See Relays
HMS-EX-011	Verify alarm and trip circuits						5
HMS-EX-012	Clean exciter cabinet					X	
HMS-EX-013	Check power leads for abrasions/cuts/general condition					X	
HMS-EX-014	Check failover of redundant components					X	
HMS-EX-015	Model Verification/Performance Testing						5
HMS-EX-016	Blackstart test					X	
	BASES AND SUPPORTS						
HMS-EX-017	Inspect for loose bolts, dowel pins or other defects. Repair as necessary.					X	
HMS-EX-018	Check frame grounding, repair as necessary.					X	
	COLLECTOR RINGS						
HMS-EX-019	Check wear, note color. Polish or recondition to assure proper operation.					X	
HMS-EX-020	Inspect brush rigging for loose bolts, connections and defective springs.					X	
HMS-EX-021	Check condition of brushes and fit. Tighten repair or replace as needed.					X	
HMS-EX-022	Test spring tension. Record tension pressure.					X	
HMS-EX-023	Brush Rigging: On generators of 500 kilowatts or synchronous motors of 500 horsepower and above, reverse field polarity.						5
HMS-EX-024	Visually inspect brushes for correct length and proper contact. Adjust as necessary.					X	

PREVENTIVE MAINTENANCE TASKS FOR EXCITERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-EX-025	Examine contact points and burnish as needed. Inspect pivot points for free movement.					X	
	COLLECTOR HOUSING						
HMS-EX-026	Clean out dust and dirt.					X	
	COIL WINDING						
HMS-EX-027	Inspect condition of exposed parts of windings, insulation, connections, clamps, end turn lashing and related items.					X	
HMS-EX-028	Examine for loose taping, mechanical damage, presenceof oil or dirt. Clean, repair and recoat with suitable insulating compound where necessary.					X	
HMS-EX-029	Measure air gap clearances and record					X	
	ROTOR						
HMS-EX-030	Check the bus connections and power cable terminations for heating and loose connections.						During Main Unit Outage
HMS-EX-031	Inspect insulators and supports for breaks, cracks, or burns.						During Main Unit Outage
	EXCITATION BREAKER						
HMS-EX-032	Perform visual inspection of excitation breaker						See Breakers
HMS-EX-033	Check contact resistance						See Breakers
HMS-EX-034	Perform breaker timing test						See Breakers
HMS-EX-035	Check electrical connections for tightness						See Breakers
	FUSES						
HMS-EX-036	Inspect fuses and fuse holders					X	
	DE-EXCITATION/CROWBAR (DXCB) MODULE						
HMS-EX-037	Check thyristors					X	
HMS-EX-038	Perform visual inspection					X	
	FAN BLOWER/MOTOR						
HMS-EX-039	Verify fan failure annunciation		X				
HMS-EX-040	inspect the blower motor for excessive vibration and noise. If excessive check for damaged or worn bearings.		X				
HMS-EX-041	Clean the motor/blower.					X	
HMS-EX-042	Check the blower motor controller, and control wiring for signs of heating, loose terminations and contactor wear.					X	
HMS-EX-043	Check for loose blower mountings.					X	
	GROUND DETECT MODULE						
HMS-EX-044	Test the ground detector module.					X	
	PROTECTIVE RELAYS						
HMS-EX-045	Check the protective relay calibration						See Relays
	SHAFT SUPPRESSION						
HMS-EX-046	Inspect shaft suppression ground brush and associated circuitry					X	

PREVENTIVE MAINTENANCE TASKS FOR EXCITERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	SPACE HEATER						
HMS-EX-047	Ensure function of cabinet heaters	X					
	FIELD FLASHING CIRCUIT						
HMS-EX-048	Check the condition of the DC field flashing contactor and arc chute.					X	

Table B-10
Fire Prevention Systems Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR FIRE PREVENTION SYSTEMS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-FS-001	Perform visual inspection of system and individual components					X	
HMS-FS-002	Test fire detection devices					X	
HMS-FS-003	Test alarm initiating devices and associated controlcircuits					X	
HMS-FS-004	Check electrical connections for tightness and condition.					X	
HMS-FS-005	Check indicating devices and associated annunciation circuits.					X	
HMS-FS-006	Check backup power on detection devices					X	
HMS-FS-007	Check operation of hydrants					X	
HMS-FS-008	Check condition of fire hoses					X	
HMS-FS-009	Check condition of fire extinguishers		X				
	WATER SUPPRESSION SYSTEMS						
HMS-FS-010	Verify operation of valves					X	
HMS-FS-011	Test insulation resistance of fire pump motors					X	
HMS-FS-012	Perform IR inspection of motors					X	
HMS-FS-013	Verify lubrication of fire pump and motor					X	
HMS-FS-014	Verify alignment of motor-pump coupling					X	
HMS-FS-015	Verify operation of discharge heads					X	
HMS-FS-016	Check piping system for leaks					X	
HMS-FS-017	Perform a complete system function test					X	
HMS-FS-018	Test initiating devices and associated control circuits.					X	
	CARBON DIOXIDE SUPPRESSION SYSTEMS						
HMS-FS-019	Verify operation of valves					X	
HMS-FS-020	Verify operation of initiating devices					X	
HMS-FS-021	Verify adequate supply of Low Pressure CO2		X				
HMS-FS-022	Verify adequate supply of high pressure CO2					X	
HMS-FS-023	Verify operation routing valve control circuits.					X	
HMS-FS-024	Verify operation air exhaust baffles in protected areas.					X	

PREVENTIVE MAINTENANCE TASKS FOR FIRE PREVENTION SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-FS-025	Verify operation of dampers					X	
HMS-FS-026	Verify operation of door releases					X	
HMS-FS-027	Verify operation of motor cut-out circuits.					X	
HMS-FS-028	Verify function of pressure switches, transducers, etc.					X	
HMS-FS-029	Hydrostatic test storage bottles						3
HMS-FS-030	Test initiating devices and associated control circuits.					X	
HMS-FS-031	Pressure test or replace flexible hoses						5
HMS-FS-032	Inspect low pressure CO2 tank						5

Table B-11
Generator Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR GENERATORS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-GN-001	Visual examination for condition of surge protective equipment.					X	
HMS-GN-002	Measure shaft and coupling runout					X	
HMS-GN-003	Visually examine bus assemblies, insulators, and supports for good condition.	X					
HMS-GN-004	Visually examine enclosures for condition.	X					
HMS-GN-005	Observe visible portions of cables to determine condition, paying particular attention to shielding and metallic- sheathed cables operating at 5 KV or above.	X					
HMS-GN-006	Insulation: PDA Test					X	
HMS-GN-007	Insulation resistance, polarization index (Megger)					X	
HMS-GN-008	CT relaying & metering: Burden Tester						2
HMS-GN-009	Time integrated meters: Statistical test					X	
HMS-GN-010	Overall: Frequency response test (offline) - MODEL VERIFICATION						5
HMS-GN-011	MW testing and/or verification (online)					X	
HMS-GN-012	Review equipment ratings						5
HMS-GN-013	Demonstrate system restoration plan performance					X	
HMS-GN-014	Clean air housing above and below, dust/brake dust, etc					X	
HMS-GN-015	Perform air gap measurements						5
HMS-GN-016	Perform stator/rotor roundness measurements						5
	GENERATOR AIR COOLERS						
HMS-GN-017	Flush coolers.					X	
HMS-GN-018	Clean exterior surfaces of coils and check for leaks.					X	
HMS-GN-019	Check interior of coils for excessive scale buildup					X	
HMS-GN-020	Operate isolation valves					X	
HMS-GN-021	Inspect plumbing/piping for leaks	X					
HMS-GN-022	Check operation of vacuum breakers		X				
HMS-GN-023	Check temperature monitoring devices					X	
	GENERATOR BRAKES						
HMS-GN-024	Measure brake shoe thickness and check condition of brake ring.					X	
HMS-GN-025	Operate brake cylinders to check for any binding, leaking, or sticking. Verify brakes applied indication.					X	

PREVENTIVE MAINTENANCE TASKS FOR GENERATORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-GN-026	Exercise isolation valves					X	
HMS-GN-027	If lubricator is not installed, operate unit jacks to lubricate brake cylinders					X	
HMS-GN-028	Check condition of brake air line filters.		X				
HMS-GN-029	Check condition of brake lubricators (if installed)		X				
	JACKING PUMP SYSTEM						
HMS-GN-030	Visually inspect motor/pump shaft alignment for excessive runout or vibration. Look for loose coupling bolts or other damaged coupling components.					X	
HMS-GN-031	Lubricate if required.					X	
HMS-GN-032	Check for leaks from casing at gasketed joints and tighten or replace gaskets as required.					X	
HMS-GN-033	Verify pump motor full load amps					X	
HMS-GN-034	Check operation of valves and gauges					X	
HMS-GN-035	Check strainers and filters					X	
HMS-GN-036	Check piping for leaks					X	
	THRUST BEARING						
HMS-GN-037	Take oil sample for analysis					X	
HMS-GN-038	Verify/calibrate high lift permissive device					X	
HMS-GN-039	Calibrate temperature sensors and oil level indicators. Verify annunciations					X	
HMS-GN-040	Check operation of thrust bearing high-pressure lubrication system oil pumps.		X				
HMS-GN-041	Check filters on high-pressure lubrication system and clean or replace as required.		X				
HMS-GN-042	Check insulation resistance					X	
HMS-GN-043	Check system for leaks	X					
HMS-GN-044	Verify pump motor full load amps					X	
HMS-GN-045	Check/verify/inspect gauges and valves	X					
HMS-GN-046	Check failover of redundant systems		X				
HMS-GN-047	Visually inspect motor/pump shaft alignment for excessive runout or vibration. Look for loose coupling bolts or other damaged coupling components.		X				
HMS-GN-048	Verify proximity probe sensors					X	
	GUIDE BEARING						
HMS-GN-049	Take oil sample for analysis					X	

PREVENTIVE MAINTENANCE TASKS FOR GENERATORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-GN-050	Check bearing clearances						5
HMS-GN-051	Calibrate temperature sensors and oil level indicators. Verify annunciations					X	
HMS-GN-052	Check insulation resistance					X	
HMS-GN-053	Check system for leaks	X					
HMS-GN-054	Check/verify/inspect gauges and valves	X					
HMS-GN-055	Verify proximity probe sensors					X	
	ROTOR						
HMS-GN-056	Visually inspect rotor spider for cracks					X	
HMS-GN-057	Visually inspect field poles and connections					X	
HMS-GN-058	Perform Insulation Resistance/Polarization Index Test						5
HMS-GN-059	AC pole drop test						5
HMS-GN-060	Field winding AC impedance						5
	STATOR						
HMS-GN-061	Inspect stator core for loose laminations, loose clamping bolts, fretting, etc.					X	
HMS-GN-062	Inspect stator windings for insulation damage					X	
HMS-GN-063	Perform power factor test						5
HMS-GN-064	Perform Insulation Resistance/Polarization Index Test						5

Table B-12
Governor Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR GOVERNORS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-GV-001	Inspect system for leaks	X					
HMS-GV-002	Take oil sample for analysis.					X	
HMS-GV-003	Inspect and clean governor cabinet components		X				
HMS-GV-004	Exercise governor hand valves and check for leaks					X	
HMS-GV-005	Clean and inspect all filters/strainers.			X			
HMS-GV-006	Inspect and clean interior of governor oil pressure tanks and sumps.						5
HMS-GV-007	Disassemble, clean, and inspect oil pumps and replace all worn parts.						5
HMS-GV-008	Check lighting, gratings, floor plates, etc., for good condition.	X					
HMS-GV-009	See that access doors and plates are tight and fit properly.	X					
HMS-GV-010	Inspect anchor bolts for indications of looseness.		X				
HMS-GV-011	Verify calibration of temperature, level, pressure, flow, and position transducers.					X	
HMS-GV-012	Measure and record full gate opening and closing time and the cushioning stroke time.					X	
HMS-GV-013	Check operation of brake circuit.					X	
HMS-GV-014	Verify tightness of all electrical connections.					X	
HMS-GV-015	Test insulation between the PMG/SSG and its support casting.					X	
HMS-GV-016	Test underspeed and overspeed trip devices and record the tripping speed.					X	
HMS-GV-017	Perform system function check.					X	
HMS-GV-018	Inspect all governor system gages, indicator lights, instruments, speed-no-load and shut-down solenoids, remote controls, remote indicators, pressure relays, safety valves, and auxiliary switches.					X	
HMS-GV-019	Verify annunciation and trip circuits.					X	
HMS-GV-020	Change filters on purification system.					X	
HMS-GV-021	Exercise valves.					X	
HMS-GV-022	Inspect condition of piping and check for leaks.					X	
	MECHANICAL GOVERNOR						
HMS-GV-023	Lubricate linkage and pivot pins.		X				
HMS-GV-024	Inspect/lubricate restoring cable mechanism, bushings, and pins				X		
HMS-GV-025	Inspect and adjust dashpot					X	

PREVENTIVE MAINTENANCE TASKS FOR GOVERNORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-GV-026	Inspect, measure, and record PMG rotor clearances.					X	
HMS-GV-027	Inspect, measure, and record flyball rotor clearances.					X	
HMS-GV-028	Measure resistance of insulated joints for restoring cable where provided.					X	
HMS-GV-029	Observe for signs of loosening or damage to dowel pins.					X	
	DIGITAL GOVERNOR						
HMS-GV-030	Inspect PLC battery					X	
	GOVERNOR ACCUMULATOR TANK						
HMS-GV-031	Check operation of clapper valve.					X	
HMS-GV-032	Clean and inspect the interiors/exteriors of the pressure tanks and sump tanks.						5
HMS-GV-033	Clean and inspect sight glasses.					X	
HMS-GV-034	Inspect and calibrate pressure relief valve.					X	
	GOVERNOR OIL PUMP						
HMS-GV-035	Visually inspect condition of governor oil pump.	X					
HMS-GV-036	Verify shaft coupling alignment.					X	
HMS-GV-037	Check motor full load amps.					X	
HMS-GV-038	Perform infrared scan of motor.					X	
HMS-GV-039	Check for proper lubrication of governor oil pump.	X					
HMS-GV-040	Check insulation resistance of governor oil pump motor.					X	
HMS-GV-041	Verify proper operation of unloaders.					X	
	SERVOMOTORS						
HMS-GV-042	Conduct visual inspection of servomotor condition and check for leaks.	X					
HMS-GV-043	Inspect servomotor, shift ring, and wicket gate linkage for proper operation.	X					
	SPEED SIGNAL GENERATOR						
HMS-GV-044	Inspect speed switches and drive gears for wear.					X	
HMS-GV-045	Lubricate pivot pins and check speed switch bearings.					X	
HMS-GV-046	Check insulation between PMG/SSG housing and the supporting frame.					X	
HMS-GV-047	Verify voltage output of PMG.					X	

PREVENTIVE MAINTENANCE TASKS FOR GOVERNORS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-GV-048	Verify speed switch setting.					X	

Table B-13
Relay and Meter Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR RELAYS AND METERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	METERS						
HMS-RM-001	Verify meter accuracy with a known source.					X	
	RELAYS						
HMS-RM-002	Perform fault load studies and recalculate settings.						5 yrs
HMS-RM-003	Perform a comprehensive inspection					X	
HMS-RM-004	Activate the lockout relay from each protective device.1						5 yrs[2]
HMS-RM-005	Verify the lockout relay and/or subsequent devices actually tripped from the protective relay action.3						5 yrs[2]
HMS-RM-006	Test initiating devices to relays						5 yrs[2]
HMS-RM-007	Perform lubrication and/or replacement of Lock Out Relays actions.						2 yrs
HMS-RM-008	Settings Verification						2 yrs
	Electromechanically Relays						
HMS-RM-009	Operational Test & Calibrate						5 yrs[2]
	Microprocessor Relays						
HMS-RM-010	Pull and Analyze Relay Event Reports			X			
HMS-RM-011	Input/Output Verification Tests						5 yrs[2]
HMS-RM-012	Measurement Channel Tests						5 yrs[2]

NERC Applicability:

Protection Systems that act to trip the generator either directly or via lockout or auxiliary tripping relays.

Protection Systems for generator step-up transformers for generators that are part of the BES.

Protection Systems for transformers connecting aggregated generation, where the aggregated generation is part of the BES (e.g., transformers connecting facilities such as wind-farms to the BES).

Protection Systems for station service or excitation transformers connected to the generator bus of generators which are part of the BES, that act to trip the generator either directly or via lockout or tripping auxiliary relays.

Notes:

[1] After the first full test of lockout relay and breakers, it may be desirable to lift the trip bus from the lockout relay so as not to repeatedly trigger the lockout—a meter may be substituted to verify contact initiation.

[2] 6 years or 12 years if monitored required by NERC PRC-005

[3] Remove control heads from CO2 bottles, initial and delay, before testing.

Table B-14
Transformer Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR TRANSFORMERS
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-TX-001	Perform visual inspection of enclosure and external equipment		X				
HMS-TX-002	Clean bushings and insulators					X	
HMS-TX-003	Check electrical connections and wiring					X	
HMS-TX-004	Verify operation of annunciation devices and circuits					X	
HMS-TX-005	Verify operation of control circuits					X	
HMS-TX-006	Verify overall operation and condition of cooling equipment\system					X	
HMS-TX-007	Inspect fan blades					X	
HMS-TX-008	Measure motor full load amps					X	
HMS-TX-009	Check insulation resistance of motors						4
HMS-TX-010	Inspect motors for excessive vibration		X				
HMS-TX-011	Inspect motors for proper lubrication					X	
HMS-TX-012	Perform power factor test of bushings and insulators						4
HMS-TX-013	Perform power factor test of winding						4
HMS-TX-014	Perform turns ratio test						4
HMS-TX-015	Perform winding resistance test						4
HMS-TX-016	Perform excitation current test						4
HMS-TX-017	Perform Capacitance Test						4
HMS-TX-018	Perform sweep frequency response analysis						4
HMS-TX-019	Verify operation of cabinet heaters	X					
HMS-TX-020	Verify function/exercise tap changers						4
HMS-TX-021	Verify grounding connections					X	
HMS-TX-022	Check calibration and verify operation of temperature, pressure, and flow indicating devices					X	
	OIL INSULATED TRANSFORMERS						
HMS-TX-023	Sample oil and perform dissolved gas analysis					X	
HMS-TX-024	Check calibration of oil level indication devices					X	
HMS-TX-025	Check oil level		X				
HMS-TX-026	Inspect piping		X				

PREVENTIVE MAINTENANCE TASKS FOR TRANSFORMERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-TX-027	Check for proper oil flow.		X				
HMS-TX-028	Inspect valves and verify proper operation					X	
HMS-TX-029	Check heat exchangers for adequate air\water flow		X				
HMS-TX-030	Verify overall operation of fire suppression system					X	
HMS-TX-031	Test fire suppression initiating devices					X	
HMS-TX-032	Verify operation of mechanical pressure relief device						4
HMS-TX-033	Verify operation of sudden pressure device						4
HMS-TX-034	Inspect conservator and bladder						4
HMS-TX-035	Verify nitrogen type and overall operation of nitrogen system		X				
HMS-TX-036	Verify nitrogen system pressures and proper operation of regulators		X				
HMS-TX-037	Inspect nitrogen system for leaks	X					
HMS-TX-038	Inspect transformer for oil leaks	X					
HMS-TX-039	Inspect oil containment for leaks	X					
HMS-TX-040	Inspect oil containment drains for blocks	X					
HMS-TX-041	Function test Buchholz relay						4
HMS-TX-042	Drain water from oil containment	X					
	DRY TYPE TRANSFORMERS						
HMS-TX-043	Perform visual inspection of winding and internal components		X				
HMS-TX-044	Clean accumulated dust and debris from winding and enclosure					X	
HMS-TX-045	Check internal connections and wiring					X	
	CURRENT TRANSFORMERS						
HMS-TX-046	Verify that current signal values are provided to the protective relays						2
	VOLTAGE TRANSFORMERS						
HMS-TX-047	Verify that voltage signal values are provided to the protective relays, meters and instruments						2
	BUSHINGS						
HMS-TX-048	Clean all exterior surfaces					X	
HMS-TX-049	Visually inspect for cracks, corrosion, and leaks		X				

PREVENTIVE MAINTENANCE TASKS FOR TRANSFORMERS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-TX-050	Inspect gaskets						4
HMS-TX-051	Inspect capacitance taps and test electrodes.						4
HMS-TX-052	Check oil level.					X	
HMS-TX-053	Perform Power Factor Test.						4
HMS-TX-054	Perform Capacitance Test						4
	TAP CHANGER - NO LOAD						
HMS-TX-055	Visually inspect.					X	
HMS-TX-056	Check contact pressure and alignment.						4
	TAP CHANGER - LOAD						
HMS-TX-057	Visually inspect.					X	
HMS-TX-058	Check contact pressure and alignment.						4
HMS-TX-059	Check Position Indicating Devices and associated control circuits.					X	
HMS-TX-060	Perform Timing Test						4

Table B-15
Turbine Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR TURBINES
Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)
(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	DRAFT TUBE DEPRESSION AIR						
HMS-TU-001	Test air control circuit operation.					X	
HMS-TU-002	Check connections, terminals and controls.					X	
HMS-TU-003	Check float switch operation.					X	
HMS-TU-004	Check transducer calibration.					X	
	TURBINE GUIDE BEARING						
HMS-TU-005	Visually check shaft and coupling for excessive runout or vibration.					X	
HMS-TU-006	Visually inspect piping and check system for leaks.					X	
HMS-TU-007	Check motor full load amps.					X	
HMS-TU-008	Check controls, wiring, terminals, and connections.					X	
HMS-TU-009	Check annunciations.					X	
HMS-TU-010	Check/verify calibration on temperature, level, pressure, and flow measurement devices.					X	
HMS-TU-011	Inspect oil strainers and clean					X	
HMS-TU-012	Sample and analyze oil					X	
HMS-TU-013	Check oil level.	X					
HMS-TU-014	Inspect heat exchanger.						5
HMS-TU-015	Verify calibration of proximity probes.						5
HMS-TU-016	Check bearing bracket and fasteners.					X	
	HEAD COVER						
HMS-TU-017	Check pumps and piping for leaks.					X	
HMS-TU-018	Take motor full load amps.					X	
HMS-TU-019	Verify function of high water alarm and pump control circuit.					X	
HMS-TU-020	Inspect the vacuum breaker.						5
HMS-TU-021	Add oil to the vacuum breaker snubbers					X	
HMS-TU-022	Inspect head cover fastener condition					X	
HMS-TU-023	Inspect head cover condition.					X	
	SHAFT SEAL						
HMS-TU-024	Check shaft seal lubricant flow and pressure measuring devices.	X					

PREVENTIVE MAINTENANCE TASKS FOR TURBINES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-TU-025	Inspect shaft seal for excessive leakage and adequate lubrication.	X					
HMS-TU-026	Evaluate condition/remaining life of shaft seal medium					X	
HMS-TU-027	Inspect shaft seal fastener condition.					X	
HMS-TU-028	Inspect shaft seal component condition.					X	
	TURBINE RUNNER						
HMS-TU-029	Examine runner/hub thoroughly for cavitation or other damage						5
HMS-TU-030	Inspect wear rings. Measure clearances.						5
HMS-TU-031	Check runner seal lubricant flow and pressure measuring devices.					X	
HMS-TU-032	Check blade seals and nose cone for leakage.						5
HMS-TU-033	Check for blade clearance and droop.						5
HMS-TU-034	Confirm blade angle travel.						5
	BUSHING						
HMS-TU-035	Verify function of centralized greasing system.		X				
HMS-TU-036	Check operation counter of automatic centralized greasing system for operating cycles.		X				
HMS-TU-037	Grease bushings not covered by centralized greasing system					X	
HMS-TU-038	When unit is unwatered, operate system to determine thatall points are receiving an adequate supply of lubricant.						5
HMS-TU-039	Check for excessive or inadequate greasing						5
HMS-TU-040	Clean up excessive grease					X	
HMS-TU-041	Check for signs of excessive bushing wear					X	
HMS-TU-042	Check grease system piping/joints for leaks					X	
	WICKET GATES						
HMS-TU-043	Inspect wicket gate linkages, shear arm, gate arm, thrust cap						5
HMS-TU-044	Check the eccentric bushing retainer bolts on each wicket gate arm.					X	
HMS-TU-045	Check for broken shear pins in all of the wicket gates.		X				
HMS-TU-046	Check shear pin annunciation system is functional					X	
HMS-TU-047	Clean out the wicket gate stem pockets.					X	
HMS-TU-048	Check the gate stem seal for excessive leakage.					X	

PREVENTIVE MAINTENANCE TASKS FOR TURBINES

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
HMS-TU-049	Check all of the wicket gate operating linkage for loose keys, pins, or bolts.					X	
HMS-TU-050	Check wicket gate position indication vs servo stroke					X	
HMS-TU-051	Measure wicket gate clearances						5
HMS-TU-052	Inspect facing plates for evidence of galling						5
HMS-TU-053	Inspect gates for smooth operation						5
HMS-TU-054	Verify condition of wicket gate end seals						5
HMS-TU-055	Inspect wicket gates for cavitation, cracking, excessive wear, corrosion						5
	STAY VANES/RINGS						
HMS-TU-056	Inspect stay vanes/rings for cavitation, cracking, excessive wear, corrosion						5
	OPERATING RING						
HMS-TU-057	Inspect operating ring for smooth operation, signs of distortion or abnormal movement					X	
HMS-TU-058	Inspect condition of operating ring for signs of cracks, excessive wear, corrosion					X	
	TURBINE SHAFT						
HMS-TU-059	Inspect shaft coupling bolts					X	
HMS-TU-060	Inspect Kaplan piston weep hole in shaft					X	
HMS-TU-061	Inspect coupling bolt guard fasteners					X	
HMS-TU-062	Inspect turbine coupling bolts					X	
HMS-TU-063	Inspect, clean, and oil shaft					X	
HMS-TU-064	Check shaft run out					X	
	DRAFT TUBE LINER						
HMS-TU-065	Check condition of interior coating						5
HMS-TU-066	Check condition of draft tube liner for evidence of corrosion, erosion, runner contact, and cavitation						5
HMS-TU-067	Inspect riveted and welded joints for leaks and corrosion						5
HMS-TU-068	Check condition of man doors, hinges, and fasteners						5

Table B-16
Water System Maintenance Tasks

PREVENTIVE MAINTENANCE TASKS FOR WATER SYSTEMS

Weekly (W); Monthly (M); Quarterly (Q); Semi-Annually (S); Annually (A); Periodic (P)

(Periodic indicated in years)

This covers raw water supply systems for cooling water systems, systems used for generator cooling, compressor cooling, hvac source, fire protection source, etc

Task #	Maintenance Task By Major Category	W	M	Q	S	A	P
	GENERAL						
HMS-WS-001	Verify flow and pressure are within system requirements		X				
HMS-WS-002	Verify function of gauges, sensors and switches					X	
HMS-WS-003	Verify annunciation to the control room					X	
HMS-WS-004	Check floats for proper level and operation					X	
HMS-WS-005	Meggar electric motors and record results					X	
HMS-WS-006	Clean strainers			X			
HMS-WS-007	Flush/clean supply and drain lines					X	
HMS-WS-008	Open tank drain to flush until water is clear		X				
HMS-WS-009	Exercise isolation valves					X	
HMS-WS-010	Check valves, piping, tanks, gauges and appurtenances for leaks					X	
HMS-WS-011	Ensure proper lubrication of pumps, shafts, bearings		X				
HMS-WS-012	Check raw water pump packing		X				
HMS-WS-013	Grease motor and pump bearings & check same for overheating		X				
HMS-WS-014	Check 'air-add' system for proper operation					X	
HMS-WS-015	Inspect condition of access					X	
HMS-WS-016	Inspect ground drainage slope and vent screens, where applicable					X	
HMS-WS-017	Inspect tank lighting system					X	

Appendix C
HydroAMP Project Codes

PLANT CODE	*PLANT NAME*	*PLANT CODE*	*PLANT NAME*	*PLANT CODE*	*PLANT NAME*
ALT	ALLATOONA	EUF	EUFAULA	LMN	LOWER MONUMENTAL
ALF	ALBENI FALLS	FTG	FORT GIBSON	MCN	MCNARY
BRK	BARKLEY	OFP	FORT PECK	MLF	MILLERS FERRY
BEA	BEAVER	OFR	FORT RANDALL	195	NARROWS
OBB	BIG BEND	FOS	FOSTER	NOR	NORFORK
BCL	BIG CLIFF	OGA	GARRISON	OOA	OAHE
197	BLAKELY MT	OGP	GAVINS POINT	OHK	OLD HICKORY
BON	BONNEVILLE	GPR	GREEN PETER	OZK	OZARK
BB	BROKEN BOW	GRF	GREERS FERRY	PHI	PHILPOTT
BUF	BUFORD	HST	HARRY S TRUMAN	RDW	RD WILLIS
BLS	BULL SHOALS	HTW	HARTWELL	RFH	RF HENRY
CRT	CARTERS	HCR	HILLS CREEK	RBR	RICHARD B RUSSELL
CHL	CENTER HILL	IHR	ICE HARBOR	RSK	ROBERT S KERR
CTM	CHEATHAM	JPP	J PERCY PRIEST	SRB	SAM RAYBURN
CHJ	CHIEF JOSEPH	JST	J STROM THURMOND	SMF	ST MARYS FALLS
CLC	CLARENCE CANNON	WDF	JM WOODRUFF	STS	ST STEPHENS
CDH	CIRDELL HULL	JDA	JOHN DAY	STK	STOCKTON
CGR	COUGAR	JHK	JOHN H KERR	TBR	TABLE ROCK
DHL	DALE HOLLOW	KEY	KEYSTONE	TKF	TENKILLER FERRY
DAR	DARDANELLE	LRL	LAUREL	TDA	THE DALLES
187	DE GRAY	LIB	LIBBY	WFG	WALTER F GEORGE

PLANT CODE	*PLANT NAME*	*PLANT CODE*	*PLANT NAME*	*PLANT CODE*	*PLANT NAME*
DEN	DENISON	LGS	LITTLE GOOSE	WBF	WEBBERS FALLS
DET	DETROIT	LOP	LOOKOUT POINT	WPT	WEST POINT
DEX	DEXTER	LOS	LOST CREEK	WHT	WHITNEY
DWR	DWORSHAK	LWG	LOWER GRANITE	WLC	WOLF CREEK

Appendix D
Hydropower Plant Personnel Training Academics and Plant Equipment Study Outline

HQUSACE (or delegate) will define minimum scope to be covered by the courses listed in this appendix.

Academics Trainee I

PHASE IA
Course Title

Learning Strategies
Basic Industrial Math
- Addition and Subtraction
- Multiplication and Division
- Fractions, Percents, Proportions, and Angles
- Metric System
- Formulas
- Introduction to Algebra

Industrial Safety
- Trades Safety: Getting Started
- Working Safely with Chemicals
- Fire Safety
- Safe Handling of Pressurized Gases and Welding
- Electrical Safety for the Trades
- Material Handling Safety
- Machine Shop Safety

Practical Measurements
- Linear and Distance Measurement
- Bulk Measurement
- Temperature Measurement
- Energy, Force, and Power
- Fluid Measurement

Introduction to Algebra, Geometry, and Trigonometry
Placement Test: Introduction to Algebra, Geometry, and Trigonometry
- Algebra: Monomials and Polynomials
- Algebra: Factoring
- Algebra: Addition and Subtraction of Fractions
- Algebra: Multiplication and Division of Fractions
- Progress Examination
- Algebra: Linear Equations
- Algebra: Simultaneous Linear Equations
- Algebra: Determinants
- Algebra: Quadratic Equations
- Progress Examination
- Algebra: Exponents
- Algebra: Radicals and Imaginary Numbers

Progress Examination
Applied Geometry
Practical Trigonometry
Logarithms
Physics, Part 1

Physics, Part 2

Phase IB
Course Title

Elements of Chemistry
Going Metric
DC Principles
- Nature of Electricity
- Circuit Analysis and Ohm's Law
- Capacitors and Inductors
- Magnetism and Electromagnetism
- Conductors, Insulators, and Batteries
- DC Motors and Generator Theory

Electronics Workbench®
Electronic Lab Manual DC
AC Principles
- Alternating Current
- Alternating Current Circuits
- Inductors in AC Circuits
- Capacitors in AC Circuits
- Transformers
- Alternators
- Electrical Energy Distribution
- Rectification and Basic Electronic Devices

Electronic Lab Manual AC
Lubrication, Part 1
Lubrication, Part 2
AC Motors, Generators, and Rectifiers
Alternators
Mechanical Power Transmission, Part 1
Mechanical Power Transmission, Part 2
Mechanical Power Transmission, Part 3
Hand and Power Tools
- Common Hand Tools, Part 1
- Common Hand Tools, Part 2
- Precision Measuring Instruments, Part 1
- Electric Drilling and Grinding Tools
- Power Cutting Tools
- Pneumatic Hand Tools
- Plumbing and Pipefitting Tools
- Electrician's Tools
- Tool Grinding and Sharpening
- Woodworking Hand Tools
- Routers, Power Planers, and Sanders
- Jacks, Hoists, and Pullers

Plant Equipment Study Outline Trainee IA

I.
Safety

A. Clearances

1. Types of Clearances

2. Types of Cards

3. Switching Orders

II.
Main Generating Units

A. Generator

1. Main Components

2. Bearings

3. Cooling System

4. Rating

5. Operations

III.
Fire Fighting Equipment and Alarms

A. Types of Fires

B. Types of Fire Fighting Equipment

C. Alarms

IV.
Station Layout

V.
Project Safety Policies

VI.
Personnel Protective Equipment

A. Ear

B. Eye

C. Foot

VII.
Project Emergency System

VIII.
Communication System

A Code Call

B. Alarms

Plant Equipment Study Outline Trainee IB

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Device Numbers and Symbols

A. Identify Symbols and Device Numbers Located on the Single Line Diagrams

III.
Main Single Line Diagram

A. Identify Symbols

B. Location and Function of all Equipment Identified on the Single Line Diagram

C. Main Single Line from Main Generator to Main Transformer

IV.
Station AC Systems

V.
Gates

A. Types

B. Operation

C. Construction

VI.
Station Air Systems

A. Station Air

1. Operating Pressure

B. Governor Air

1. Operating Pressure

C. Brake Air

1. Operating Pressure

D. Air Compressors

1. Cooling

2. System Layout

VII.
Fire Suppression Systems, CO_2 and Fine Water Mist

A. Uses and Hazards

1. Safety Precautions

B. Systems

1. Generator

2. Oil Storage

3. Other

VIII.
SCADA

IX.
Generator Start Sequence

A. Flow Chart Showing All Auxiliaries with Brief Explanations

X.
Testing/Maintenance Equipment

A. Mechanical Testing Equipment

B. Electrical Testing Equipment

Academics Electrician Trainee II

Phase IIA
Course Title

Fundamentals of Power Plant Operation, Part 1
Fundamentals of Power Plant Operation, Part 2
Fundamentals of Power Plant Operation, Part 3
Station Power
Reading Prints and Schematics
- Introduction to Print Reading
- Dimensioning
- Tolerancing and Symbols
- Sectional Views and Simplified Drafting
- Building Drawings
- Electrical Drawings and Circuits
- Electronic Drawings
- Hydraulic and Pneumatic Drawings
- Piping: Drawings, Materials, and Parts
- Welding Symbols
- Sheet Metal Basics
- Sketching

Working Safely with Electricity
Electric Power Generating Stations, Part 1
Electric Power Generating Stations, Part 2
Industrial Materials and Components
- Metal Processing
- Ferrous Metals
- Nonferrous Metals
- Identification of Metals
- Nonmetallic Materials
- Plastics, Elastomers, and Composite Materials
- Wood Products
- Paints and Adhesives
- Fasteners
- Introduction to Pumps and Compressors
- Introduction to Bearings and Seals
- Introduction to Power Transmission
- Industrial Relays, Contractors, and Solenoids

PHASE IIB
Course Title

Analog Circuit Measurement
- Basic Test Equipment
- Troubleshooting with Volt-Ohm-Milliamp Meters (VOMs)
- Using Basic Oscilloscopes

LAB Manual Electric Measurements A23
Maintenance and Troubleshooting
- Preventive Maintenance
- Preventive Maintenance Techniques
- Predictive Maintenance
- Predictive Maintenance Vibration Analysis
- Predictive Maintenance Advanced Topics

Fundamental Principles of Rigging Technology
Planning the Rigging Operation
Working with Rigging Tools, Part 1
Working with Rigging Tools, Part 2
Rigging: Lifting Equipment and Applications, Part 1
Rigging: Lifting Equipment and Applications, Part 2
Electrical Grounding
Electricity, Part 1
Electricity, Part 2
Electricity, Part 3
Switchgear
Electrical Equipment
- Conductors and Insulators in Industry
- Working with Conduit
- Electrical Boxes
- Industrial Enclosures and Raceways
- Connecting Electrical Equipment, Part 1
- Connecting Electrical Equipment, Part 2
- Industrial Fuses
- Industrial Circuit Breakers
- Plugs, Receptacles, and Lamp Holders
- Industrial Switches
- Industrial Relay Ladder Logic
- Industrial Relays, Contractors, and Solenoids

Plant Equipment Study Outline Electrician Trainee IIA

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Water Systems

A. Raw Water System

B. Potable Water System

III.
HVAC

A. Description

B. Maintenance Performed

IV.
Excitation System

A. Description

B. Purpose

C. Operation

V.
Station DC System

A. Description of System

B. Batteries

1. Type

2. Charges

3. Ground Detection System

C. Battery Chargers

VI.
Insulation Types

A. Types

B. Temperatures Associated with Each Type

VII.
Unit Start/Stop (Overview)

A. Tie a Main Unit to the Line Covering all Auxiliaries

Plant Equipment Study Outline Electrician Trainee IIB

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Generator

A. Name Plate Data

B. Type

C. Construction

III.
Limits, Alarms, and Name Plate Data

A. Load Limits

B. Temperature Limits

1. Generator

2. Transformer

C. Name Plate Data

1. Generator

2. Transformer

3. Exciter

4. Turbine

D. Annunciation

IV.
Governor

A. Description of system

B. Operation

V.
Synchronizer

A. Description of System

B. Operation

VI.
Unit Start/Stop

A. Tie a Main Unit to the Line Covering All Auxiliaries and Contacts Also Stop Unit.

1. Release Brakes

2. Synchronizer

3. Close Breaker

Academics Electrician Trainee III

Phase IIIA
Course Title

Electricity and Magnetism, Part 1
Electricity and Magnetism, Part 2
Electricity and Magnetism, Part 3
Principles of AC Circuits, Part 1
Principles of AC Circuits, Part 2
Principles of AC Circuits, Part 3
Principles of AC Circuits, Part 4
Electric Power Substations, Part 1
Electric Power Substations, Part 2
Industrial DC Motors
Industrial AC Motors
Controlling Industrial Motors
DC Machines, Part 1
DC Machines, Part 2
Repairing DC Motors and Generators, Part 1
Repairing DC Motors and Generators, Part 2
Transformers
Electrical Wiring Practices
Conduit and Conductors, Part 1
Conduit and Conductors, Part 2

Phase IIIB
Course Title

Electrical Blueprint Reading
Reading Electrical Schematic Diagrams
National Electrical Code
Underground Power Systems
Transformer Operation
Distribution and Power Transformers
Local Distribution of Electrical Power
Instrument Transformers
Electrical Measuring Instruments, Part 1
Electrical Measuring Instruments, Part 2
Electrical Measuring Instruments, Part 3
Electric Power Measurements, Part 1
Electric Power Measurements, Part 2
Storage Batteries
Electric Lamps, Part 1
Electric Lamps, Part 2
Lighting Control

Plant Equipment Study Outline Electrician Trainee IIIA

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
SCADA

A. Inputs

B. Outputs

C. Control Provided

D. Firewalls

III.
Interlocks

A. Purpose and Types

1. Generator

2. Breakers

3. Disconnects

4. Metal Clad Switchgear

5. Control Circuits (Relaying, etc.)

6. Governors

IV.
Transformer (Power, CT, PT, and Relaying)

A. Station Service Transformer

1. Description

2. Cooling

B. Current Transformers (CTs) and Potential Transformers (PTs) Found in One Line

C. Main Power Transformer

1. Description

2. Purpose

3. Construction

4. Auxiliaries

a. Hot Spot Indicator

b. Cops Tank

c. Cooling Groups

d. Alarms

e. Tap Changer

V.
Breakers (Molded Case, 480v, 15kv, Controls)

A. Molded Case Breakers

1. Tests

2. Overloads

3. Maintenance

B. 480v Breakers

1. Mechanical Operation (Prints)

2. Electrical Operation (Prints)

3. Maintenance

4. Inspection

C. 15kv Breakers

1. Mechanical Operation (Prints)

2. Electrical Operation (Prints)

3. Maintenance

4. Inspection

VI.
Selsyn Sets/Remote Indicating Devices

A. Theory of Operation

B. Where Utilized

C. Maintenance

VII.
Testing/Maintenance Equipment

A. Megger

1. Theory of Operation

2. Where Used

B. Multimeter

1. Theory of Operation

2. Where Used

C. Clamp-On Ammeter

1. Theory of Operation

2. Where Used

D. High Potential

E. Trip Testing

F. Other

Plant Equipment Study Outline Electrician Trainee IIIB

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
MODs

A. Controls

B. Proper Operation

C. Adjustments

D. Testing

III.
Annunciation System

A. Components

1. Relays

2. Trouble Contacts

3. DC Supply

B. Schematic Diagrams

C. Maintenance

IV.
Crane (Powerhouse, Single Line)

A. Mechanical

1. Hoist

2. Cable Drums

3. Cables

B. Capacity

1. Main Hoist

2. Auxiliary Hoist

C. Maintenance

D. Electrical

1. Source of Supply

2. Controls

3. Limit Switches

E. Variable Frequency Drives

V.
Breakers (Switchyard Controls)

A. Switchyard Breakers

1. Mechanical Operation (prints)

2. Electrical Operation (prints)

3. Trip Free

4. Capacitive Trip

5. Maintenance

6. Inspection

VI.
Insulation (Oil and Gas)

A. Types and Locations

B. Testing

C. Inspection

D. Purifying

VII.
Preventative Maintenance and Testing

A. Megger

1. Theory of Operation

2. Where Used

B. Multimeter

1. Theory of Operation

2. Where Used

C. Clamp-On Ammeter

1. Theory of Operation

2. Where Used

D. High Potential

E. Tripping Test

F. Other

VIII.
Inspection

A. Motor Control Centers

1. Breakers

2. Contactors

3. Space Heaters

4. Wiring

5. Terminal Blocks

B. Motors

1. Windings

2. Slip Rings

3. Wiring

4. Insulation

C. Generators

1. Exciters

2. Speed Switches

3. Winding

4. Insulation

5. Surge Protection

D. Breakers

1. Contacts

2. Gas Pressure

3. Operating Springs

E. Recording Data

Academics Electrician Trainee IV

Phase IVA
Course Title

Voltage Regulators for Generators
Symmetrical Components
Protective Relaying, Part 1
Protective Relaying, Part 2
Voltage Regulation of Distribution Systems
DC Generators and Motors
Industrial Motor Controls
Analog Electronic Components
- Basic Semiconductor Components: Diodes
- Basic Semiconductor Components: Transistors
- Switching Devices
- Electronic Sensors
- Special Rectifiers: Electron Tubes
- Optoelectronic and Fiber Optic Components
- Electronics Hardware

Electrical Power Distribution and Transmission for the Technician

Phase IVB
Course Title

Motor Control Fundamentals (for Programmable Logic Controllers)
Industrial Motor Control (for Programmable Logic Controllers)
Industrial Motor Control (for Programmable Logic Controllers)
Industrial Motor Applications
Alternating Current Motors
Fractional Horsepower Motors
Repairing Fractional Horsepower Motors
AC Motor Repair, Part 1
AC Motor Repair, Part 2
Reconnecting Induction Motors
Basic Electronic Circuits
- Rectifiers and Power Supplies
- Amplifiers
- Oscillators
- Modulation and Detection Circuits
- Switching Circuits
- Logic Circuits
- Gating and Counting Circuits
- Pulse and Digital Circuits

Introduction to Microprocessors
- Introduction to Computers
- Introduction to Microprocessor Applications
- Microprocessor Basics, Part 1: Underlying Principles and Concepts
- Microprocessor Basics, Part 2: Overview of What's in a Microprocessor
- Progress Examination
- Progress Examination Booklet

Controls for Air Conditioning
Design of Alternating Current Machines

Plant Equipment Study Outline Electrician Trainee IVA

I.
Clearance Procedure

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Carrier Current

A. Definition

B. How to Use in Relaying

C. Step Distance

III.
Switching

A. Operation

B. Precautions

C. Switch Out Switchyard Breaker Maintaining Service to Line

IV.
Relays (Transformers, Generator, Line)

A. Generator

1. Theory of Operation

2. Inputs (CTs, PTs)

B. Transformer

1. Theory of Operation

2. Inputs (CTs, PTs)

C. Line

1. Theory of Operation

2. Inputs (CTs, PTs)

V.
Lightning Arrestors and MV Fuses

A. Theory of Operation

B. Break Down and Reseal Voltages

C. Maintenance and Inspection

VI.
Programmable Logic Controllers

Plant Equipment Study Outline Electrician Trainee IVB

I.
Generator Cable System

A. Alarms and Limits

B. Potheads

C. Maintenance and Test

II.
Remote and Supervisory Control Systems (includes Load Control)

A. Principles of Operation

B. Features of Operation to Include Trip, Alarm, and Reset Circuits

C. Maintenance

III.
Line Relays, Ground Detectors, and Telemetering

A. Line Relays

B. Ground Detectors

C. Telemetering

IV.
Main Unit and Associated Equipment (includes Disassembly and Reassembly)

A. Describe a Main Generator

B. Disassembly and Reassembly of a Main Unit

1. Protective Relays

2. Governors

3. Turbines

4. Annual Inspections

5. Unit CO_2 system

V.
Trip Test

A. Methods and Procedures

B. Safety

VI.
Materials, Supplies, and Spare Parts

A. Purchase Request & Commitments (PR&Cs)

B. Logging

C. Maintaining Supply Levels

VII.
Duties and Responsibilities

A. Duties of Power Plant Electrician "A"

B. Responsibilities to the Job and Public

VIII.
Supervisory Skills

A. Explain the current performance appraisal system.

B. How does a discussion of an employee's performance help them?

C. What are performance standards?

D. How should an employee be commended for a job well done?

E. How should you handle employees working under your supervision?

F. How can you help build a good public image for USACE?

G. Which trait is more important and why: a high degree of loyalty or a high degree of technical competence?

H. How would you react to an order or directive you did not agree with?

I. Which is more important and why: Personnel functions or seeing that the work is done?

J. Explain the Equal Employment Opportunity (EEO) program.

IX.
Safety

A. EM 385-1-1, working knowledge

B. EM-385-1-31

C. Local Hazardous Energy Control Program (HECP) and Implementing Letter, detailed knowledge

NOTE: Since this is the "topping out" examination, the study questions and equipment from phases IA, IB, IIA, IIB, IIIA, IIIB, and IXA are to be included and selected questions will be asked to determine the understanding and retention of all previous training.

Academics Mechanic Trainee II

Phase IIA
Course Title

Fundamentals of Power Plant Operation, Part 1
Fundamentals of Power Plant Operation, Part 2
Fundamentals of Power Plant Operation, Part 3
Reading Prints and Schematics
- Introduction to Print Reading
- Print Reading Symbols and Abbreviations
- Dimensioning and Tolerancing
- Print Reading Applications
- Building Drawings
- Electrical Drawings and Circuits
- Electronic Drawings
- Hydraulic and Pneumatic Drawings
- Piping: Drawings, Materials, and Parts
- Welding Symbols
- Sheet Metal Basics Sketching

Working Safely with Electricity
Electric Power Generating Stations, Part 1
Electric Power Generating Stations, Part 2
Industrial Materials and Components
- Metal Processing
- Ferrous Metals
- Nonferrous Metals
- Identification of Metals
- Nonmetallic Materials
- Plastics, Elastomers, and Composite Materials
- Wood Products
- Paints and Adhesives
- Fasteners
- Introduction to Pumps and Compressors
- Introduction to Bearings and Seals
- Introduction to Power Transmission

Phase IIB
Course Title

Maintenance and Troubleshooting
- Preventative Maintenance
- Preventative Maintenance Techniques
- Predictive Maintenance
- Predictive Maintenance Vibration Analysis
- Predictive Maintenance Advanced Topics

Fundamental Principles of Rigging Technology
Planning the Rigging Operation
Working with Rigging Tools, Part 1
Working with Rigging Tools, Part 2
Rigging: Lifting Equipment Applications, Part 1
Rigging: Lifting Equipment Applications, Part 2
Electric Power Substations, Part 1
Electric Power Substations, Part 2

Hydraulic Power Basics
Hydraulic Components: Actuators, Pumps, and Motors
Hydraulic Components: Conductors, Conditioners, and Fluids
Hydraulic Power System Control
Interpreting Hydraulic System Schematics
Hydraulic Power System Troubleshooting
Principles of Mechanics, Part 1
Principles of Mechanics, Part 2
Bench Work

Plant Equipment Study Outline Mechanic Trainee IIA

I.
Clearance Procedure

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Main Unit Excitation System and Voltage Regulator

A. Description

B. Purpose

C. Operation

III.
Governor Overview

A. Purpose

B. Type

C. Operation

D. Oil Pressures

E. Overspeed

F. Modes

IV.
Water Systems

A. Raw Water System

B. Potable Water System

V.
Sewage System

A. Type

B. Operation

C. Maintenance

VI.
Craft Skills, Tools, and Equipment

A. Thread Types

B. Proper Torque Wrench Use

C. File Types

D. Lathe

E. Milling Machine

F. Safety

VII.
Flood Control Operations

VIII.
Insulation types

A. Types and Locations

B. Temp Limits

IX.
Limits, Alarms and Nameplates

A. Load Limits

1. Generator

2. Turbine

B. Temperature Limits

1. Generator

2. Turbine

3. Transformer

C. Name Plate Data

1. Transformers

2. Turbines

3. Generators

4. Exciters

D. Annunciation

1. Purpose

2. Description

X.
Seals

A. (O-ring, Mechanical, Braided Packing, Chevron, Gasket, etc.)

B. Types

C. Uses

D. Installation

E. Adjustment

XI.
Welding, Soldering, Brazing, and Computer Aided Design (CAD) Welding

A. Types

B. Methods

C. Safety

Plant Equipment Study Outline Mechanic Trainee IIB

I.
DC Systems

A. Explain the complete DC system, including battery chargers and station batteries.

B. Read print and explain the system operation.

II.
Unit Start/Stop

A. Start a main unit using the centralized control point.

III.
Switching Operations

A. Purpose

IV.
Pumps

A. Types

B. Centrifugal

C. Positive Displacement

D. Principle Operating Characteristics

E. Troubleshooting

V.
Machine Projects

Academics Mechanic Trainee III

Phase IIIA
Course Title

Basic Machining Skills
- Practical Shop Math, Part 1
- Practical Shop Math, Part 2
- Practical Shop Measurement
- Safe Shop Practices
- Properties and Classifications of Metals
- Progress Examination
- Using Shop Drawings, Process, and Routing Sheets, Part 1
- Using Shop Drawings, Process, and Routing Sheets, Part 2
- Layout
- Progress Examination
- Metal-Cutting and Machine Tooling, Part 1
- Metal-Cutting and Machine Tooling, Part 2
- Metal-Cutting Machinery, Part 1
- Metal-Cutting Machinery, Part 2
- Fundamentals of Grinding
- CNC Machine Tool Features and Applications
- Progress Examination
- Progress Examination Booklet

Fundamentals of Metal Cutting
Fundamentals of Grinding
Tool Grinding
Drilling, Part 1
Drilling, Part 2
Shapers, Slotters, and Keyseaters
Milling Machine Fundamentals
Milling Machines
Milling Machine Practice, Part 1
Milling Machine Practice, Part 2
Lathes, Part 1
Lathes, Part 2
Lathes, Part 3
Lathes, Part 4
Lathes, Part 5

Phase IIIB
Course Title

Toolmaking, Part 1
Toolmaking, Part 2
Toolmaking, Part 3
Toolmaking, Part 4
Reading Piping Prints
Bearings and Seals, Part 1
Bearings and Seals, Part 2
National Plumbing Code
Principles of Heating, Ventilating, and Air Conditioning, Part 1
Principles of Heating, Ventilating, and Air Conditioning, Part 2
Condensers
Sheet Metal Hand Processes, Part 1
Sheet Metal Hand Processes, Part 2
Sheet Metal Machine Processes
Jig and Fixture Making, Part 1
Jig and Fixture Making, Part 2
Pressure Vessel and Tank Print Reading
Industrial Plumbing and Pipefitting
- The Trades of Plumbing and Pipefitting
- Pipes, Fittings, and Valves
- Plumbing and Pipefitting Tools
- Joining and Assembling Pipes
- Supporting, Installing, and Testing Pipes
- Plumbing Fixtures and Appliances
- Tanks, Pumps, and Boilers
- Insulation for Piping and Ducting

Plant Equipment Study Outline Mechanic Trainee IIIA

I.
Safety and Operation of Equipment

A. Grinder

B. Lathe

C. Milling Machine

D. Welder

E. Drill Press

F. Portable Hand Power Tools

II.
Turbines

A. Assembly/Disassembly

B. Component Parts

C. Type

D. Lubrication

1. Wicket Gates

2. Bearings

3. Automatic System

E. Operation

1. Shear Pins

2. Vacuum Breakers

3. Servomotors

III.
Station Service

IV.
Bearings

A. Generator

1. Thrust

a. Alignment Procedure and Methods

b. Loading

c. Bridge Leveling

d. Babbitt Inspection Methods

e. Lowering Device

2. Guide

a. Type

b. Installation and Removal

c. Babbitt Inspection Methods

B. Turbine – Guide

1. Type

2. Installation and Removal

3. Babbitt Inspection Methods

C. Wicket Gate

1. Type

2. Installation and Removal

3. Inspection Methods

D. Lubrication Systems

E. Operation – Temperature Limits

V.
Powerhouse Elevator

A. Inspection Criteria

B. Load Testing

C. Maintenance

VI.
Main Power Transformers

Plant Equipment Study Outline Mechanic Trainee IIIB

I.
Safety

A. EM 385-1-1, Safety Manual

B. ER 385-1-31, Safe Clearance Procedures

II.
Governor

A. Type

B. Construction

C. Operation (PMG/SSG, Compressor, Overspeed Mechanism, Oil System, Pilot Valve, Speed Droop Mechanism)

III.
Air Conditioning, Heating and Ventilating Equipment

A. Operation

B. Control

C. Maintenance

IV.
Air Compressors

A. Generator Brake System

B. Station Air System

C. Unloader Valves

V.
Cranes

A. Powerhouse Crane

1. Type

2. Safety

3. Operation

4. Capacities

5. Load Testing Critical Lift

6. Hand Signals

7. Inspections

B. Gantry Crane

1. Type

2. Safety

3. Operation

4. Capacities

5. Load Testing

6. Critical Lift

7. Hand Signals

8. Inspections

C. Rigging

1. Chain Falls

2. Wire Rope

3. Slings

4. Shackles

5. Load Angle Calculations

VI.
Unit Unwatering

VII.
CO_2 Systems

A. Explain CO_2 system for a main generator, read schematic and flow diagram.

B. Explain CO_2 system for the oil room, read schematic and flow diagram.

C. Explain why CO_2 is a suitable fire extinguishing agent for power plants.

Academics Mechanic Trainee IV

Phase IVA
Course Title

Fundamentals of Welding, Part 1
Fundamentals of Welding, Part 2
Safety in Welding and Cutting
Gas Welding Equipment, Part 1
Gas Welding Equipment, Part 2
Gas Welding Techniques, Part 1
Gas Welding Techniques, Part 2
Gas Welding Techniques, Part 3
Arc Welding Equipment, Part 1
Arc Welding Equipment, Part 2
Arc Welding Equipment, Part 3
Shielded Metal Arc Welding Techniques, Part 1
Shielded Metal Arc Welding Techniques, Part 2
Arc Welding of Low Carbon Steel, Part 1
Arc Welding of Low Carbon Steel, Part 2
Arc Welding of Alloy Steels and Iron
Arc Welding of Nonferrous Metals and Overlaying
Gas Metal Arc Welding Funds (GMAW or metal inert gas, MIG)
Fabrication of Pipe by Welding, Part 1
Fabrication of Pipe by Welding, Part 2

Phase IVB
Course Title

Controls for Air Conditioning
Hardening and Tempering
Gas Cutting
Pumps, Part 1
Pumps, Part 2
Pumps, Part 3
Air Compressors, Part 1
Air Compressors, Part 2
Diesel Engine Parts, Part 1
Diesel Engine Parts, Part 2
Fuel Systems, Part 1 (Diesel)
Fuel Systems, Part 2 (Diesel)
Cooling, Air Intake, and Exhaust Systems (Diesel)
Maintenance of Lubricating and Fuel Systems (Diesel)
Maintenance of Air Intake, Exhaust, and Cooling Systems (Diesel)
Maintenance of Electrical Systems (Diesel)
Air Conditioning Systems, Part 1
Air Conditioning Systems, Part 2

Plant Equipment Study Outline Mechanic Trainee IVA

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Welding

A. Type

B. Methods

C. Safety

III.
Soldering and Brazing

A. Types of Solder and Uses

B. Types of Brazing Rods and Uses

C. Heat Requirements

D. Torch and Gas Safety

IV.
Bearing Alignment

A. Bearing Removal

B. Bearing Installation

C. Bearing Loading

D. Bearing Alignment

V.
Machine Shop

A. Shop Equipment

B. Components of the Shop

C. Safety Precautions

VI.
Oil Systems

A. Purifier

B. Operations

C. Maintenance

VII.
Flow Meters

VIII.
Supervisory Skills

A. Recordkeeping

B. Planning

C. Responsibilities

IX.
Cavitation

A. Causes

B. Methods of Repair

1. Surface Preparation

2. Welding Procedures

a. Rods –Types and Use

b. Wire –Types and Use

c. Preheat

d. Post-Heat

e. Non Destructive Testing Methods

3. Grinding Procedures

C. Safety

X.
Metallurgy

Plant Equipment Study Outline Mechanic Trainee IVB

I.
Power Plant and Dam Piping

A. Explain the layout using piping schematics.

B. Plumbing Fixtures and Techniques

1. Sanitary Facilities

2. Valves, Strainers, etc.

II.
Maintenance of Generator and Turbine Equipment to Include Disassembly, Inspection, Reassembly, and Adjustments

A. Disassembly and Reassembly

1. Lifting Devices and Handling Parts

2. Use Manufacturer Prints and Reference Points

3. Cleaning, Care, Protection, and Identification of Parts

4. Recordkeeping, as Found and as Left Readings

B. Adjustments

1. Arrangement of Plumbs and Dial Indicators, and the Points and Methods of Adjustment

2. Procedure for Replacing the Main Turbine Shaft Packing

3. Adjustments of Main Unit Bearings

4. Bolt and Nut Locking Devices

5. Evaluation and Adjustment of Turbine Equipment, Gate, Linkage, Servomotors, and Clearances

III.
Maintenance of Governor and Associated Equipment to Include Disassembly, Inspection, Reassembly, and Adjustments

A. Disassembly and Reassembly

1. Filter Oil, Refill, and Purge Governor Oil System

2. Evaluation of the Performance of Governor, and Inspection of Component Parts according to Manufacturer's Instruction Book

3. Adjustments After Startup, Offline Stability (Purpose and Procedures of Test)

IV.
Inspection and Maintenance of Power Plant and Dam Structures

A. Power Plant Roof, Concrete, Steel, Wood, and Floors

B. Dam Concrete, Steel, Earth Fill, Drains, Riprap, and Piezometers

V.
Gates and Bulkheads

A. Construction and Inspection

B. Method of Placing and Checking In Service, and Storage

C. Preventative Maintenance Including Cathodic Protection

VI.
Testing Procedures and Data Analysis

A. Oil Testing

B. Gauge Testing

VII.
PR&Cs and Record Keeping

A. PR&Cs

B. Recordkeeping

VIII.
Working Relationship Skills

A. Explain the employee performance appraisal system now in use.

B. How does a discussion of an employee's performance help them to do a better job?

C. What are performance standards?

D. How should an employee be commended for a job well done?

E. How should you handle an employee working under your supervision?

F. How can you help build a good public image of USACE?

G. Which trait is more important and why? A high degree of loyalty or a high degree of technical competence?

H. If you receive an order or directive that you did not agree with, how would you react?

I. List the advantages of good housekeeping.

J. Which is more important and why? Personnel functions or seeing that the work is done.

K. Explain the EEO program.

IX.
Duties and Responsibilities

A. What are your responsibilities as Power Plant Mechanic "A"?

X.
Safety

A. EM 385-1-1, working knowledge

B. EM 385-1-31

C. HECP and Implementing Letter, detailed knowledge

NOTE: Since this is the "topping out" examination, the study questions for IA, IB, IIA, IIB, IIIA, IVA and IVB are to be included. Selected questions will be added to this examination to determine the understanding and retention by the trainee of all previous training areas.

Academics Operator Trainee II

Phase IIA
Course Title

Fundamentals of Power Plant Operation, Part 1
Fundamentals of Power Plant Operation, Part 2
Fundamentals of Power Plant Operation, Part 3
Station Power
Reading Prints and Schematics
    Introduction to Print Reading
Print Reading, Symbols and Abbreviations
    Dimensioning and Tolerancing
    Print Reading Applications
    Building Drawings
    Electrical Drawings and Circuits
    Electronic Drawings
    Hydraulic and Pneumatic Drawings
    Piping: Drawings, Materials, and Parts
    Welding Symbols
    Sheet Metal Basics
    Sketching
Working Safely with Electricity
Electric Power Generating Stations, Part 1
Electric Power Generating Stations, Part 2
Industrial Materials and Components
    Metal Processing
    Ferrous Metals
    Nonferrous Metals
    Identification of Metals
    Nonmetallic Materials
    Plastics, Elastomers, and Composite Materials
    Wood Products
    Paints and Adhesives
    Fasteners
    Introduction to Pumps and Compressors
    Introduction to Bearings and Seals
    Introduction to Power Transmission
Electrical Equipment
    Conductors and Insulators in Industry
    Working with Conduit
    Electrical Boxes
    Industrial Enclosures and Raceways
    Connecting Electrical Equipment, Part 1
    Connecting Electrical Equipment, Part 2
    Industrial Fuses
    Industrial Circuit Breakers
    Plugs, Receptacles, and Lampholders
    Industrial Switches
    Industrial Relay Ladder Logic
    Industrial Relays, Contactors, and Solenoids

Phase IIB
Course Title

Analog Circuit Measurement
- Basic Test Equipment
- Troubleshooting with Volt-Ohm-Milliamp Meters (VOMs)
- Using Basic Oscilloscopes

Lab Experiments for Block A23
Maintenance and Troubleshooting
- Preventive Maintenance
- Preventive Maintenance Techniques
- Predictive Maintenance
- Predictive Maintenance: Vibration Analysis
- Predictive Maintenance: Advanced Topics

Electrical Grounding
Electricity, Part 1
Electricity, Part 2
Electricity, Part 3
Switchgear
Controls for Air Conditioning
Principles of Heating, Ventilating, and Air Conditioning, Part 1
Principles of Heating, Ventilating, and Air Conditioning, Part 2
Air Conditioning Systems, Part 1
Air Conditioning Systems, Part 2

Plant Equipment Study Outline Operator Trainee IIA

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Water Systems

A. Raw Water System

B. Potable Water System

III.
HVAC

A. Description

B. Maintenance Performed

IV.
Excitation System

A. Description

B. Purpose

C. Operation

V.
Station DC System

A. Description of System

B. Batteries

1. Type

2. Charges

3. Ground Detection System

C. Battery Chargers

VI.
Insulation Types

A. Types

B. Temperatures Associated with Each.

VII.
Unit Start/Stop (Overview)

A. Tie a main unit to the line covering all auxiliaries.

Plant Equipment Study Outline Operator Trainee IIB

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Transformer

A. Station Service Transformer

1. Description

B. Main Power Transformer

1. Description

III.
Limits, Alarms, and Name Plate Data

A. Load Limits

B. Temperature Limits

1. Generator

2. Transformer

C. Name Plate Data

1. Generator

2. Transformer

3. Exciter

4. Turbine

IV.
Governor

A. Description of system

B. Operation

V.
Protective Relaying

A. Description

B. Purpose

C. Operation

VI.
Annunciator System

A. Description

Academics Operator Trainee III

Phase IIIA
Course Title

Electric Power Substations, Part 1
Electric Power Substations, Part 2
Industrial DC Motors
Industrial AC Motors
Controlling Industrial Motors
DC Machines, Part 1
DC Machines, Part 2
Transformers
Reading Electrical Schematic Diagrams
Electrical Blueprint Reading
Reading Piping Prints
Basic Electronic Components and Schematic Symbols
Understanding and Using Electronic Diagrams
Telemetering
Electricity and Magnetism, Part 1
Electricity and Magnetism, Part 2
Electricity and Magnetism, Part 3
Principles of AC Circuits, Part 1
Principles of AC Circuits, Part 2
Principles of AC Circuits, Part 3
Principles of AC Circuits, Part 4

Phase IIIB
Course Title

Transformer Operation
Distribution and Power Transformers
Underground Power Systems
Local Distribution of Electrical Power
Instrument Transformers
Electrical Measuring Instruments, Part 1
Electrical Measuring Instruments, Part 2
Electrical Measuring Instruments, Part 3
Electric Power Measurements, Part 1
Electric Power Measurements, Part 2
Storage Batteries
Electric Lamps, Part 1
Electric Lamps, Part 2
Lighting Control
Bearings and Seals, Part 1
Bearings and Seals, Part 2
Power Line Calculations

Plant Equipment Study Outline Operator Trainee IIIA

I.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

II.
Oil Circuit Breaker

A. Explain the purpose, construction, operation (electrical and mechanical), rating, and inspection.

III.
Circuit Breakers and Disconnects

A. Explain the purpose, construction, operation (electrical and mechanical), rating, and inspection.

B. Motor and Hand Operated Disconnects

1. Explain the purpose, construction, operation (electrical and mechanical), rating, and inspection.

IV.
Protective Relays

A. Generator Relays

B. Transformer Relays

C. Bus Relays

D. Line Relays

V.
Air Systems

A. Explain the station air system (include piping layout, compressors, and controls).

VI.
Switching, Generation, and System Low Frequency for Normal and Emergency Operating Procedures

A. Explain normal operating procedures.

B. Explain emergency operating procedures.

VII.
Interlocks

A. Purpose and Types

1. Generator

2. Breakers

3. Disconnects

4. Metal Clad Switchgear

5. Control Circuits

6. Governors

Plant Equipment Study Outline Operator Trainee IIIB

I.
Read and explain the following for local and remote plants:

A. Read and explain the main single-line diagrams.

B. Read and explain the AC auxiliary power single line diagram.

II.
Station Service Equipment for Local and Remote Plants

A. Explain in detail the normal AC power supply for station service (transformer).

B. Explain in detail the emergency AC power supply for station service (hydro or diesel generator).

III.
Direct Current System for Local and Remote Plants

A. Batteries (including control schematics, chargers, inspections, construction, and operation)

B. Fault Detection and Isolating a Ground

IV.
Oil Systems

A. Explain in full the lubricating oil system.

B. Explain in full the insulating oil system.

V.
Air Conditioning and Ventilating Equipment

A. Explain the operation of the air conditioning equipment, compressors, controls, ducts, etc.

B. Explain the ventilating equipment, fans, ducts, controls, etc.

VI.
Water Systems

A. Explain the raw water system, piping, pumps, controls, etc.

B. Explain thoroughly the cooling water system.

VII.
Breakers (All Voltages and Types, AC and DC)

A. Construction

B. Operation

C. Inspection

VIII.
Flowmeters

A. Type

B. Operation

C. Maintenance

Academics Operator Trainee IV

Phase IVA
Course Title

Power Line Calculations
Voltage Regulators for Generators
Protective Relaying, Part 1
Protective Relaying, Part 2
Voltage Regulation of Distribution Systems
Industrial Motor Control
Analog Electronic Components
Basic Semiconductor Components: Diodes
Basic Semiconductor Components: Transistors
Switching Devices
Electronic Sensors
Special Rectifiers: Electron Tubes
Optoelectronic and Fiber Optic Components
Electronics Hardware
Electrical Power Distribution and Transmission for the Technician

Phase IVB
Course Title

Motor Control Fundamentals (for Programmable Logic Controllers)
Industrial Motor Control (for Programmable Logic Controllers)
Industrial Motor Control (for Programmable Logic Controllers)
Industrial Motor Applications
Alternating Current Motors
Fractional Horsepower Motors
Power Plant Economy
Efficiency Tests
Reconnecting Induction Motors
Repairing Fractional Horsepower Motors
AC Motor Repair, Part 1
AC Motor Repair, Part 2
Basic Electronic Circuits
- Rectifiers and Power Supplies
- Amplifiers
- Oscillators
- Modulation and Detection Circuits
- Switching Circuits
- Logic Circuits
- Gating and Counting Circuits
- Pulse and Digital Circuits

Introduction to Microprocessors
- Introduction to Computers
- Introduction to Microprocessor Applications
- Microprocessor Basics, Part 1: Underlying Principles and Concepts
- Microprocessor Basics, Part 2: Overview of What's in a Microprocessor
- Progress Examination
- Progress Examination Booklet

Analog Systems

Plant Equipment Study Outline Operator Trainee IVA

I.
Local and/or Remote Plants, Single- and Three-Line Diagrams

A. Single-line diagram

B. Three-line diagram

II.
Local and/or Remote Plants, Voltage Regulator, and Excitation System

III.
Annunciator System

A. Block Diagram and Operation

IV.
Telephone System

A. Commercial and Plant Communication Systems, Use and Operation

V.
Local and Remote Plants Main Generating Unit

A. Ask three "what would happen and what would you do" questions.

B. Explain in detail any main unit auxiliary system.

C. Explain the load and operating temperature limits for a main unit.

VI.
Local and Remote Plants Transformers

A. Give the load and temperature limits for a main transformer.

B. Ask three "what would happen and what would you do" questions.

C. Explain in detail any transformer protection.

VII.
Local and Remote Plants Relays

A. Name, give the type, and describe each relay used on the main generator and transformer.

B. What would happen if any two of these relays operated, to include record keeping?

VIII.
Governors and Governor Systems

A. Explain governor operation, to include purpose and component parts.

IX.
Lightening Arrestors and High Voltage Fuses

A. Description

B. Rating

X.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

Plant Equipment Study Outline Operator Trainee IVB

I.
Local and Remote Plants, Single- and Three-Line Diagrams

A. Read, relate to, and explain any equipment shown on the main station or station service single-line prints.

B. Read and explain the station three-line diagrams.

II.
Control Room Boards

A. Instrumentation

1. Explain the current and potential supply for any meter in the control room.

B. Temperature recorders

1. Explain the power supply for any chart drives in the control room.

C. SCADA Operation and Description

D. Load Control Equipment

III.
Local and Remote Plants, Main Unit, and Auxiliary Equipment

A. Describe a main generator and turbine.

B. Protective devices, limits, and alarms

C. Your Responsibility During Annual Inspections

D. Cooling Water System

E. Lubrication

F. CO_2 System/Fire Protection

G. Water Depressing System

H. Brakes and Jacks

IV.
Governors

A. PMG/Static Controller

B. Speed Switches

C. Pressure Switches

D. Oil System

E. Operation

V.
Local and Remote Plants, Station Service

A. Station Service Transformer

B. Station Service Generator (Hydro or Gas)

C. 480-volt Bus

D. Breakers and Auxiliary Boards

E. Emergency Procedures

G. DC System

VI.
Duties and Responsibilities

A. Duties of Power Plant Operator "A"

B. Responsibilities to the Job and to the Public

VII.
Local and Remote Plants, Main Power Transformers, Transmission Lines, and Buses

A. Cooling System

B. Moisture Prevention

C. Load Limits and Alarms

D. Emergency Procedures

E. Relays

VIII.
Safety

A. EM 385-1-1, working knowledge

B. Local Safety Appendix

Academics Electronics Mechanic Trainee II

Phase IIA
Course Title

Fundamentals of Power Plant Operation, Part 1
Fundamentals of Power Plant Operation, Part 2
Fundamentals of Power Plant Operation, Part 3
Reading Prints and Schematics
- Introduction to Print Reading
- Dimensioning
- Tolerancing and Symbols
- Sectional Views and Simplified Drafting
- Building Drawings
- Electrical Drawings and Circuits
- Electronic Drawings
- Hydraulic and Pneumatic Drawings
- Piping: Drawings, Materials, and Parts
- Welding Symbols
- Sheet Metal Basics
- Sketching

Industrial Materials and Components
- Metal Processing
- Ferrous Metals
- Nonferrous Metals
- Identification of Metals
- Nonmetallic Materials
- Plastics, Elastomers, and Composite Materials
- Wood Products
- Paints and Adhesives
- Fasteners
- Introduction to Pumps and Compressors
- Introduction to Bearings and Seals
- Introduction to Power Transmission

Phase IIB
Course Title

Analog Circuit Measurement
- Basic Test Equipment
- Troubleshooting with Volt-Ohm-Milliamp Meters (VOMs)
- Using Basic Oscilloscopes

Experiments Electrical Measurements A23
Maintenance and Troubleshooting
Preventive Maintenance
Preventive Maintenance Techniques
Predictive Maintenance
Predictive Maintenance Vibration Analysis
Predictive Maintenance Advanced Topics
Electricity Part 1
Electricity Part 2
Electricity Part 3
Transformers

Reading Electrical Schematic Drawings
Transformer Operation
Protective Relaying
Industrial Motor Control
Basic Electronic Components and Symbols
Understanding and Using Electronic Diagrams
Telemetering

Plant Equipment Study Outline Electronics Mechanic Trainee IIA

I.
HECP Procedures

A. ER 385-1-31

B. HECP Supplement

C. Protective Grounds

II.
Hand Tools

III.
Definitions

A. Electronic

B. Electrical

IV.
Diagrams

A. Electronic

B. Electrical

C. Telephone

V.
Power Supplies

A. Batteries

B. Chargers

C. AC Power Supplies

D. Rectifiers

VI.
Oscillator Circuits

VII.
Test Equipment

A. Multimeters

B. Oscilloscope

C. Grounding and Insulation

VIII.
Radio Installation, Vehicle

Plant Equipment Study Outline Electronic Mechanic Trainee IIB

I.
HECP

A. HECP Supplement

B. Switchyard Clearances

II.
Radios

A. AM

B. FM

C. Grounding and Insulation

III.
Microwave

IV.
Public Address Systems

V.
Lightning Protection

VI.
Test Equipment – Includes Safety

VII.
Cables – RF, Audio, Fiber Optic, Telephone

Academics Electronics Mechanic Trainee III

Phase IIIA
Course Title

- Analog Electronic Components
  - Basic Semiconductor Components: Diodes
  - Basic Semiconductor Components: Transistors
  - Switching Devices
  - Electronic Sensors
  - Special Rectifiers: Electron Tubes
  - Optoelectronic and Fiber Optic Components
  - Electronics Hardware
- Basic Electronic Circuits
  - Rectifiers and Power Supplies
  - Amplifiers
  - Oscillators
  - Modulation and Detection Circuits
  - Switching Circuits
  - Logic Circuits
  - Gating and Counting Circuits
  - Pulse and Digital Circuits
- Component Testers
- Digital Test Equipment
- Reactive Circuits
  - Reactance and Impedance
  - Resonant Circuits
  - Applications and Troubleshooting of Resonant Circuits
- Workbench Lab
- Electronic Systems
  - Electronic Devices and Amplification
  - Audio and RF Circuits
  - Oscillators, Feedback, and Waveforms
  - Electronic Power Supply Systems
  - Industrial Amplification Systems
  - Servo and Control Systems
  - Pulse and Logic Circuits
  - Programmable Controllers and Microprocessors
- Troubleshooting Electronic Equipment and Systems
  - Industrial Electronic Troubleshooting
  - Electronic Troubleshooting. Of Ind. Motor Controls
  - Troubleshooting Sensing Devices and Systems
  - Troubleshooting Individual Control Systems and Output Devices
  - Troubleshooting Individual Computer Systems and Software
  - Industrial Computer Networks
- How to Solder and Desolder
- Measurements Trainer

Phase IIIB
Course Title

Motor Control Fundamentals (for Programmable Logic Controllers)
Industrial Motor Control (for Programmable Logic Controllers)
Industrial Motor Control (for Programmable Logic Controllers)
Digital Electronics
Basic Industrial Computer Systems
- Industrial Computer Fundamentals
- Digital and Analog Systems
- Software and Programming
- Progress Examination
- Computer-Aided Control Systems
- Interfacing Principles
- Progress Examination
- Progress Examination Booklet

Introduction to Microprocessors
- Introduction to Computers
- Introduction to Microprocessor Applications
- Microprocessor Basics, Part 1: Underlying Principles and Concepts
- Microprocessor Basics, Part 2: Overview of What's in a Microprocessor
- Progress Examination
- Progress Examination Booklet

Fiber Optics
Fiber Optics Training Kit

Plant Equipment Study Outline Electronics Mechanic Trainee IIIA

I.
Care, Use, Operation, and Maintenance of Test Instruments, Machine Tools, Power Tools, and Hand Tools to Include Safety Practices

A. Test Instrument Leads

B. CTs and PTs

C. Test Blocks

D. Draw a typical circuit and explain the operation of some of the following: multimeter, megger, insulation tester, multirange voltmeter, DC ammeter, AC ammeter, Wheatstone Bridge.

E. Name and describe the common types of meter movement.

F. Define ohms per volt.

G. What is the function of meter rectifiers?

H. How are ammeters connected in a circuit? Voltmeters?

I. What is the general rule for safe insulation resistance?

J. When are instrument transformer used?

K. Describe proper care and storage methods of test instruments.

L. Analysis and use of data acquired from instruments.

II.
Electrical Maintenance Materials and Their Uses

A. Make a list of insulation tapes, varnishes, and materials, and explain the factors which govern their use.

B. Make a list of solvents and cleaning materials and explain the factors which govern their use.

C. State safety requirements to be followed using any of the above.

III.
Industrial Motors and Controls

A. Describe and give uses of the following types of motors: squirrel cage, synchronous, universal, wound rotor, split phase, shaded pole, capacitor, polyphase, selsyn, shunt, series, and repulsion.

B. What are the three basic types of motor control? (manual, semi-automatic, and automatic, including PLCs)

C. What are the two types of starting control? (full voltage and reduced voltage) Explain the how and why of each.

D. Name some ways of accomplishing reduced voltage starting.

E. Explain how to reverse the rotation on the following motors: split phase, capacitor start, and polyphase.

F. Describe the construction and operation of the bi-metal and molten-alloy thermal overloads.

G. Explain the basic concepts of static control. Name five basic types of static switching devices and indicate what each one is equivalent to in electromagnetic systems.

IV.
Basic Electronics

A. Describe the function of the following circuits and explain what type of tube is used in each circuit, electron tube circuit, rectifier, oscillator, amplifier. Describe the types of rectifiers.

B. Name the classes of amplifiers and give uses: A, B, C, AB, push-pull, thyratron, control circuits.

C. Semiconductor Diodes and Transistors

1. Types: PNP, NPN, FET, and SCR. Use test equipment to determine types in circuits.

2. IC Circuits

3. Amplified Circuits

4. AM and FM, Detection, Discriminator Circuits

V.
Protective Relays (Explain the Purpose and Principle, Results, and Effects of Operation)

A. Generator Relays

B. Transformer Relays

C. Bus Relays

D. Line Relays

VI.
Schematic Diagrams (Read and Explain the Schematic Diagram for Any Four of the Following)

A. Circuit Breakers, All Voltages and Types

B. Motor-Operated Disconnect

C. Generator Relays

D. Transformer Relays

E. Bus Relays

F. Line Relays

VIII.
Basic Dielectric Theory

A. Insulation Characteristics

B. Basic Dielectric Structure

C. Dielectric Testing Methods

IX.
Safety

A. 385-1-1 working knowledge

B. Local Appendix Safety Policy

X.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lift

Plant Equipment Study Outline Electronic Mechanic Trainee IIIB

I.
Plant Familiarization

A. Main Single-Line Diagrams

B. Three Line Diagrams

C. Control and Relaying Circuits

II.
RF Theory

A. Modulation

1. Wave Forms

2. Types

B. Demodulation

1. Wave Forms

2. Types

C. Communications

1. Data

a. Types and Uses

2. Voice

a. Types and Uses

b. Use, Handling and Care of Test Equipment

III.
Unit Inspections

A. Generator – Stators, Fields, Exciters, etc.

B. Auxiliary Equipment – PTs, surge protection, etc.

C. Breakers – ACBs, VCBs, etc.

D. Relays

E. System Testing – Offline, Trip Testing, Gate and Blade Timing, etc.

F. Record Keeping

G. Safety – Coordination

IV.
Transformer Inspections

A. Winding Test

B. Bushing Test

C. Auxiliary Equipment – Neutral Reactor, TRO, etc.

D. Relays

E. System Testing – Trip Testing, etc.

F. Record Keeping

G. Safety – coordination

H. Insulating and Lubricating Oils

1. Use

2. Handling

3. Testing

V.
Safety

A. EM 385-1-1, working knowledge

B. Local Safety Appendix

VI.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

Academics Electronics Mechanic Trainee IV

Phase IVA
Course Title

Microprocessor Trainer Lab 8085 Processor
Electronic Process Control ***(REPLACES B13)***
Industrial Microprocessors ***(REPLACES B12)***
Industrial Electronic Circuit Applications
- Interfacing Process Variables
- Motor Control and Servo Systems
- Numerical Control Systems
- Progress Examination
- Programmable Controllers
- Industrial Robots
- Progress Examination
- Progress Examination Booklet

Basic Industrial Electronic System Applications
- Voltage and Frequency Controllers
- Nondestructive Test Equipment
- Resistance Welding Equipment
- Progress Examination
- Dielectric and Induction Heating
- Cranes, Scales, and Materials Handling
- Progress Examination
- Progress Examination Booklet

Advanced Troubleshooting Techniques
- Approach to Troubleshooting
- Analysis of Systems
- Test Equipment Applications
- Progress Examination
- Safe Troubleshooting Practices
- Troubleshooting Industrial Systems, Part 1
- Troubleshooting Industrial Systems, Part 2
- Progress Examination
- Progress Examination Booklet

Phase IVB
Course Title

PC Maintenance & Repair

Plant Equipment Study Outline Electronics Mechanic Trainee IVA

I.
Plant Familiarization

A. Main Single-Line Diagrams

B. Power System Operation Diagrams (PSOs)

C. Three-Line Diagrams

D. Control and Protective Relaying Circuits

II.
Supervisory Control and Data Acquisition Systems

A. Maintenance

B. Programing

C. Input/Output Points

D. Printer Maintenance

E. Communications

F. Watt Hour Metering

G. Trouble Shooting and Test Procedures

III.
Switchyard Circuit Breakers

A. Cable System

B. Operations

C. Test Procedures

1. Doble

2. Meggering

3. Bridging

IV.
Carrier Current Equipment

A. Operations and Equipment

B. Cable System (Wave Traps and Coupling Capacitor)

C. Test Procedures, Readings and Adjustments

1. Transmitters

2. Receivers

3. Voice Circuits

V.
Pilot Wire Equipment

A. Basic Equipment

B. Cable System

C. Relaying

D. Test Procedures/Operational Check

VII.
Lightning Protection

A. Types and Uses (Surge Protection, Lightning Arresters, etc.)

B. Test Procedures

VII.
Main Generating and Station Service Generating Units

A. Construction

1. Stator

2. Rotor

3. Exciters

4. Grounding System

B. Troubleshooting and Non-Routing Test Procedures

VIII.
Safety

A. EM 385-1-1, working knowledge

B. Local Safety Appendix, detailed knowledge

IX.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

Plant Equipment Study Outline Electronics Mechanic Trainee IVB

I.
Blueprint Reading – Read and Interpret Prints

A. Main Single-Line Diagrams

B. Main Three-Line Diagrams

C. Power System Operation (PSO) Diagrams

D. Control, Interlocking, Protection Circuits

II.
Circuit Breakers – All Voltages and Types

A. Construction

B. Operation

C. Maintenance

D. Testing Procedures

III.
Protective Relays and Devices – Construction, Operation, Maintenance, and Test Procedures

A. Generator

1. Main

2. Station Service

B. Transformer

1. Main

2. Station Service

C. Bus

D. Line

E. Ground Detectors

1. Alternating Current

2. Direct Current

F. Lightning Arrestors and Capacitors

G. Main Generator

1. Excitation System

2. Voltage Regulator

3. Governor System

4. Start and Shutdown System

5. Rotor

6. Stator

IV.
Main Transformer

A. Neutral Reactor

B. Temperature Control

C. Bridging

D. Construction

V.
Oils – Includes Test Procedures

A. Insulating

B. Lubricating

VI.
Meters – Construction, Operation, Maintenance, and Test Procedures

A. Analog

1. Indicating

2. Recording

B. Digital

1. Recording

2. Totalizing

C. Incremental

VII.
SCADA – Construction, Operation, Maintenance, and Test Procedures

A. Master Station

B. Remote Station

1. Interposing relays

2. Control circuits

3. Analog and status points

C. Data Loggers

VIII.
Microwave, Telemetering, and Carrier Equipment

A. Microwave

B. Carrier

C. Telemetering

IX.
Diagnostic Software

A. ProTest, Doble, Fiber Optic, Jem Ware, Adtran, etc.

X.
Insulation Testing

A. Theory

B. Procedures

C. Standard and Special

XI.
Circuit Measurements

A. Potential Transformers

B. Current Transformers

C. Voltage Circuits

D. Current Circuits

E. Phase Angles

XII.
Leadership Skills

A. Communication/Coordination with Craft Personnel During Equipment Outages

XIII.
Safety

A. EM 385-1-1, working knowledge

B. Appendix Safety Policy, detailed knowledge

XIV.
Clearance Procedures

A. Responsibilities

B. Switching Order

C. Protective Cards

D. Lockbox Procedures

E. Switching Permit

F. Transfer of Clearance

G. Temporary Lifts

TRAINING FOR ADVANCEMENT TO THE SENIOR OR EQUIVALENT LEVEL
SUMMARY OF SENIOR LEVEL EVALUATION COMPONENTS

1. Leadership Training, for example:
    a. Civilian Education System (CES) Foundation Course
2. OJTs, for example:
    a. Hold Main Unit or Transformer clearance, perform AHA, and conduct safety meeting.
    b. Coordinate and facilitate a black start for training purposes.
    c. Demonstrate manual start/stop of a Main Unit.
    d. Act as shop POC for purchases, spill prevention, and Safety Data Sheets (SDS) information.
    e. Complete Cadet Basic Training (CBT) or have completed a formal leadership development program.
    f. Demonstrate proficiency using Excel, Word, and PowerPoint.
    g. Demonstrate proficiency using FEM.
    h. Act as POC for Main Unit annual or five-year outage, including hydroAMP data entry.
    i. Plan and execute a confined space entry.
    j. Plan and execute a critical lift.
    k. Serve as acting (or job shadow) senior craftsman or duty operator.
    l. Complete Operations daily log entries, monthly reports, yearly reports, OMBIL and DOE reporting requirements.
    m. Perform operations at remote plants.
3. Safe Clearances and Safety, for example:
    a. Hazardous Energy Control Program (HECP)
    b. Safe Clearance Forms
    c. Main Unit, Main Power Transformer, and Line Clearances
    d. Log Book Entries (Operators only)
    e. Record Keeping
    f. PHA/AHA
    g. PPE
    h. Confined Spaces
    i. Critical Lifts
    j. Arc Flash Policy and Procedures
    k. Emergency Policies and Procedures
4. Switching and Valving (Operators only), for example:
    a. Main Unit Switching
    b. Line Switching
    c. Main Unit Valving
    d. Governor Valving
    e. Main Power Transformer Switching and Valving
5. Standard Operating Procedures (Operators only), for example:
    a. Drought Contingency Plan
    b. Outage Request Procedure

c. Emergency Action Plan
d. Discharge Tables

6. Plant Automation and Controls (Operators only), for example:
    a. SCADA/Generic Data Acquisition and Control System (GDACS)
    b. Temperature Monitoring Systems
    c. Waterview
    d. Daily Log Computers
    e. Equipment Monitoring Screens
7. Administrative Skills, for example:
    a. Recordkeeping
    b. Planning
    c. Responsibilities
    d. Procurement
8. Leadership Skills
    a. Communication
    b. Time Management
    c. Conflict Resolution
    d. Decision-Making
9. Environmental, for example:
    a. Material Safety Data Sheets (MSDS)
    b. Spill Plans
    c. Oil Analysis
10. Maintenance Program, for example:
    a. FEM
    b. Biennials/Quadrennials
    c. Plant Tour
    d. Advanced Troubleshooting
    e. Trainee Advancement
    f. Dam Safety
    g. Power Review Program
    h. NERC Compliance
    i. Condition Assessment
    j. New Equipment QA (Contract Work)
11. Technical, for example:
    a. One Line
    b. Generator Start/Stop
    c. Switching
    d. Station AC System
    e. Station DC System

Hydropower Training Program OJT Check Sheet	Phase of Training	Training Class/Power Plant
Trainee Name:		
Trainee will be instructed on each OJT task by a qualified person. Trainee and Trainer/Reviewer will date and initial form at the conclusion of each initial training session. The trainee will be given the rest of the phase to demonstrate the independent ability to successfully perform each of the OJT tasks described below, at which time both the trainee and the trainer/reviewer will initial and date verifying final completion.		

OJT Task	Date of Initial	Initials	Date of Final	Initials

Trainee Signature:	Date:
Reviewer Signature:	Date:
Supervisor Signature:	Date: