RECLAMATION

Managing Water in the West

Facilities Instructions, Standards, and Techniques
Volume 5-14
Temporary Release (Expires 12/18/2016)

Electrical Safety Program

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

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14. ABSTRACT
This document's purpose is to establish clear and consistent instructions and procedures for dealing with electrical safety and arc flash hazards. The Electrical Safety Program establishes coordinated and consistent procedures and operating criteria for safe and reliable operation and maintenance of those facilities. Program goals are defined in the document. This program prescribes procedures and minimum performance for the safety of maintenance and operations employees. These instructions and procedures supplement the requirements in the Reclamation Safety and Health Standards. Adherence to these procedures will enable workers to perform their duties with maximum confidence and safety. In the event of a difference between the requirements in this Facilities Instructions, Standards, and Techniques and those contained in the Reclamation Safety and Health Standard, the more rigorous requirement must apply.

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Acronyms and Abbreviations

AC	Alternating current
ANSI	American National Standards Institute
AR	Arc rated
ARM	Arc flash reduction mode
ASTM	American Society for Testing and Materials
ATPV	Arc thermal protection value
cal/cm^2	Calories per square centimeter
CFR	Code of Federal Regulations
COR	Contracting Officer's Representative
COTR	Contracting Officer's Technical Representative
CT	Current transformer
CARMA	Capital Asset Resource Management Application
DC	Direct current
ESP	Electrical Safety Program
FESP	Facility Electrical Safety Program
FIST	Facilities Instructions, Standards, and Techniques
FR	Fire rated
HECP	Hazardous Energy Control Program
HEWP	Hazardous Energy Work Permit
IEEE™	Institute of Electrical and Electronics Engineers
JHA	Job hazard analysis
NFPA	National Fire Protection Association
O&M	Operations and maintenance
OSHA	Occupational Safety and Health Administration
PEBs	Power Equipment Bulletins
PPE	Personal protective equipment
PPG	Personal protective grounding
PRO	Power Resources Office
PRO&M	Power Review of Operations and Maintenance
PRIS	Power Review Information System
PT	Potential transformer
QPAL	Electrical Qualified Personnel Authorization List
RSHS	Reclamation Safety and Health Standards
RO	Responsible official
SOPs	Standing Operating Procedures
TSC	Technical Service Center

Table of Contents

Page

1.0 Introduction

{Each Reclamation facility must develop a facility electrical safety program (FESP).} The FESP will consist of a copy of the Facilities Instructions, Standards, and Techniques (FIST) 5-14, Electrical Safety Program (ESP) in its entirety, with specific facility requirements integrated and identified by highlighting and/or underlining. The FESP as defined in this document will consist of the following:

1) Identifying tasks for which interaction with energized electrical equipment is required.
2) Performing and understanding the Arc Flash Hazard Analysis Report, which predicts the incident energy of an arc flash for a specified set of conditions for energized electrical equipment in a facility.
3) Developing procedures based on risk assessments to include implementation of safety control strategies to reduce the potential hazards an employee may be exposed to when interacting with or working on energized electrical equipment.
4) Documenting mitigation strategies to reduce employee exposure. Reclamation has established a goal to reduce the potential hazards an employee may be exposed to. This document addresses this exposure goal, and acknowledges that time is needed to implement mitigation techniques to reduce the potential hazards that an employee may encounter.
5) Providing Job Hazard Analyses (JHAs) and Hazardous Energy Work Permits (HEWPs).
6) Documenting employee training.

1.1 Purpose

The purpose of the FIST Volume 5-14 is to establish a Bureau of Reclamation ESP. The ESP establishes Reclamation's exposure goals and includes basic electrical safety in the workplace, electrical safe working practices, policies, documentation, and standard operating procedures (SOPs).

{Reclamation's overall goal has always been, and will remain, that an electrically safe work condition must be established for the performance of all work by de-energizing and locking out all electrical equipment utilizing approved hazardous energy control procedures. When establishment of an electrically safe work condition is not feasible, the requirements set forth in this document must be followed.}

This document also defines the safety control strategies to be used when employees will be exposed to electrical shock hazards **>50 volts** or incident energies **>1.2 cal/cm^2**.

This document follows the requirements established by the Occupational Safety and Health Administration (OSHA), National Fire Protection Association Standard 70E (NFPA 70E), and other referenced standards.

1.2 Scope

The ESP applies to all tasks and activities when interaction with energized electrical equipment at Reclamation owned and operated facilities. This includes all powerhouses, water infrastructures, spillways, fish facilities, pumping stations, irrigation and domestic water facilities, warehouses, garages, machine shops, office buildings, maintenance shops, laboratories, or similar type facilities.

1.3 Reclamation Standard Practices

Refer to the Reclamation Manual Directive and Standard FAC 04-14, *Power Facilities Technical Documents* (http://www.usbr.gov/recman/fac/fac04-14.pdf), for more details concerning Reclamation Standard Practices.

The FIST Revision Request Form (POM-226)[1] is used to request changes to a FIST document. The request will include a summary of the changes and a basis for the revision or new FIST. These forms will be submitted to the Manager, Power Resources Office (PRO).

Reclamation Manual FAC P14, *Power Operations and Maintenance Technical Requirements* (http://www.usbr.gov/recman/fac/facp-14.pdf), defines the use of **[bold and bracketed text]**.

1.4 Effect of Section Headings

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

1.5 Interpretations

The stated interpretations for the following words must be applied throughout this document:

[1] Available to Reclamation employees through Reclamation's Forms SharePoint® site at https://dosp/inforesc/itservices/PrintandDup/forms/POM%20Forms/POM-226.pdf.

(1) "May" – permissive choice or discretionary action.

(2) "Must" – Mandatory or obligation.

(3) "Must Not" – Prohibition.

(4) "Should" – Advisory or recommendation.

(5) "Will" – Mandatory, but allowing the employee or party some discretion as to when, where, or how.

"Switchman" may refer to a switch operator of either gender.

1.6 Reclamation's Exposure Limits

{Employee exposure to incident energy >40 cal/cm^2 is prohibited.}

{When the incident energy is >40 cal/cm^2, safety control strategies must be implemented to reduce the exposure to the employee.} **>40 cal/cm^2** represents incident energy so high that personal protective equipment (PPE) is not adequate to protect the worker from possible death.

Reclamation's goal is to reduce employee exposure to electrical shock hazards **>50 volts** and to reduce arc flash hazards with incident energies **>8 cal/cm^2.**

2.0 Responsibility and Authority

2.1 Senior Advisor, Hydropower

The Senior Advisor, Hydropower, sponsors the ESP. The Senior Advisor, Hydropower, is also responsible for oversight of the overall program.

2.2 Regional Director

[The Regional Director is responsible for:

(1) Implementing the ESP.

(2) Approving or delegating authority for personnel to identify, approve, and document specific instances when Reclamation's goals cannot be met due to system configuration or design of equipment.]

2.3 Managers

[The manager at each facility or area office must ensure that:

(1) The FESP is implemented, documented and kept up to date.

(2) A responsible official (RO) is designated and identified.

(3) The regional power manager and regional director are notified of tasks that will expose any employee to >8 cal/cm^2 or >50 volts.

(4) A comprehensive review of the FESP is performed annually.

(5) A service agreement or contract to perform or update the Arc Flash Hazard Analysis Report for their facility is scheduled.

(6) Employees are trained.

(7) An Electrical Qualified Personnel Authorization List (QPAL) is maintained.

(8) All unexpected events are reported, investigated, documented, tracked and corrected.

(9) Appropriate personal protective equipment (PPE) is available for employees.

(10) Applicable contract documents include provisions to address electrical safety.]

2.4 Supervisors

[Supervisors must ensure that:

(1) The FESP is followed and safe work procedures are utilized.

(2) Personnel are trained and qualified for the tasks they are expected to perform.

(3) Risk Assessments and JHAs are developed and implemented that address shock and arc flash hazards and related safety control strategies.

(4) Documentation — including JHAs, HEWPs, Hazardous Energy Control Procedures (HECPs), and special work permits — is complete, accurate, followed, filed, and documents retained per FIST 1.1 timeframe.]

2.5 Employees

[Employees must:

(1) Be familiar with, and comply with the policies and procedures in the FESP.

(2) Be properly trained on the FESP and the tasks they are expected to perform and follow their training.

(3) Participate in JHA and safe work procedure development and briefings.

(4) Notify their supervisor of any observed discrepancies in the program, equipment, labeling, procedures, etc.]

2.6 Contracting Officer's Representative (COR) and/or Contracting Officer's Technical Representative (COTR)

[The COR or COTR must ensure that:

(1) The contractor is informed of known hazards that relate to the contract work.

(2) Facility personnel are familiar with the hazards related to the work performed by the contractor.

(3) The contractor is provided a copy of the FESP.]

2.7 Manager, PRO

[The Manager, PRO, is responsible for the following:

(1) Providing resources and guidance for program support.

(2) Providing standardized training materials to be used by the facilities for classroom training.

(3) Collecting and analyzing data from Facility Electrical Safety Program (FESP) reviews, Power Review of Operations and Maintenance (PRO&M)[2] recommendations, and Unexpected Event Reporting[3] documentation, to evaluate effectiveness of program implementation.

(4) Reviewing and updating FIST 5-14 as necessary to meet regulatory requirements.

(5) Providing feedback on the program to the regional directors, as necessary.

[2] See FIST Volume 6-5, *Power Review of Operations and Maintenance Program.*
[3] See FIST Volume 6-3, *Unexpected Event Reporting*.

(6) Reviewing and taking appropriate action on suggested revisions, comments, and concerns for this program.]

2.8 Responsible Official (RO)

[The RO at each facility or area office must ensure that the requirements of the FESP are applied and followed by all employees.]

3.0 Facility Electrical Safety Program (FESP) and Procedures

{Each area office or facility must use this FIST 5-14 to develop a FESP.} The FESP consists of a copy of the FIST 5-14 in its entirety, with the specific facility's requirements integrated and identified by highlighting and/or underlining. The overall program will address all known situations that could lead to the potential exposure of an employee to an electrical hazard.

Whenever Reclamation employees are required to perform work at transferred works or other agencies where the FIST 5-14 is not utilized, the management of the facility being visited should ensure that personnel are provided information on their local program. In the absence of a local program, the authorized employee should follow the guidance implemented by FIST 5-14 and NFPA 70E. Do not perform work that cannot be performed safely under an approved procedure.

(1) {The FESP must:

(a) At a minimum, be as restrictive as the FIST Volume 5-14 requirements;

(b) Be readily available at each facility;

(c) Be made available to each employee;

(d) List facility-specific abbreviations and terms;

(e) Include an inventory of tasks that are expected to be completed on energized electrical equipment that do not meet the requirements for "normal operations" or exceptions;

(f) Include documented risk assessments for energized electrical work that does not meet the requirements for "normal operations" or exceptions;

(g) Include documented safe work procedures for energized electrical work. The FESP will identify where the procedures are located, e.g. SOPs, Capital Asset Resource Management Application (CARMA) job plans, JHAs, etc.;

(h) Be reviewed for accuracy and signed by the responsible manager at least every three years.}

(2) {A current QPAL must:

(a) Be maintained at each facility.

(b) Identify each employee and their level of qualification:

(i) Qualified Employee: ≤600 volt nominal;

(ii) Qualified High-Voltage Employee: >600 volt nominal;

(iii) Qualified Crane/Heavy Equipment Operator Electrical Safety;

(iv) Qualified Energized Electrical Employee (Personnel who work within limited approach boundaries of exposed energized conductors and circuit parts).

(c) Be reviewed and signed by the responsible manager at least annually, and when changes are made.}

3.1 Developing Safe Work Procedures

{Safe work procedures must be developed when an HEWP is required on energized electrical equipment.}

[Safe work procedures must be developed prior to work on any energized electrical equipment and for tasks that interacts with energized electrical equipment.] Develop FESP safe work procedures in consultation with personnel who are familiar with performing and interpreting arc flash and shock hazard analysis, with various methods of safety control strategies, and with the equipment and tasks to be performed. Resources may include facility staff, TSC, PRO, and regional and area office staff.

[The development of safe work practices must make use of the hierarchy of safety control strategies identified in Section 5.3 to reduce the hazards that employees will be exposed to.] (Refer to NFPA 70E Annex "E" E.3 for guidance.)

These procedures will become part of the overall FESP. They will direct activity appropriate to the tasks to be performed. The procedures must be peer reviewed by a second qualified person. **[The FESP must identify the locations of all such safe work procedures (e.g., Facility SOPs, JHAs, HECPs, locally generated procedures, job plans, etc.).]**

Where multiple pieces of equipment have the same operating criteria and hazards, (e.g. multiple devices in the same panel) one safe work procedure can cover these pieces of equipment, as long as the individual devices are listed.

3.2 FESP Program Review

[The FESP must be reviewed to verify that the established procedures are in place and properly being applied, annually.] (Note: It is suggested that the FESP program review coincide with the PRO&M reviews, so they can be checked by a person who is not normally involved with the local program.)

[The review must be properly documented and maintained, e.g., recorded in CARMA with the name(s) of the person(s) who performed the review, the date of the review, and copies of the review check sheet, recommendations and corrective actions. Any recommendations must be entered into the Power Review Information System (PRIS) or an applicable recommendations tracking system (e.g., DSIS). A report of the findings will be filed and a copy sent to the regional director, regional power manager, and Manager, PRO, identifying deficiencies, recommendations, and corrective actions.]

[Managers must ensure that the FESP review adequately addresses the following areas:

(1) **The FESP is properly implemented.**

(2) **The FESP's requirements are enforced.**

(3) **Procedures are properly used and documented.**

(4) **Employees are familiar with their responsibilities.**

(5) **Training requirements are met and documented.**

(6) **Corrective action plans have been prepared or completed to address previously identified recommendations.**

(7) **The Incident Energy Analysis and procedures are current for the existing equipment installation and configuration. This includes newly installed or modified electrical equipment.**

(8) **Recommendations from the Arc Flash Hazard Analysis have been reviewed, implemented and entered into PRIS or an applicable recommendation tracking system.**

(9) **Energized electrical safe work procedures (Section 3.1) are reviewed.]**

(Note: An example of a FESP review check sheet is available in Appendix E.)

4.0 Training Program

4.1 Purpose

{Personnel must be trained to the level of work they will be expected to perform. The training must include basic electrical awareness training for both qualified and unqualified personnel, as well as any specific electrical related safety practices outlined in this section that are necessary for their safety.}

A tiered training approach has been developed for different categories of qualified electrical workers. The use of the enclosed training proficiency sheets is highly recommended, but facilities may also use their own versions or modify these to fit their specific training requirements. The defined levels of qualification are:

(1) Qualified Employee: ≤ 600 volt nominal

(2) Qualified High-Voltage Employee: > 600 volt nominal

(3) Qualified Crane/Heavy Equipment Operator Electrical Safety

(4) Qualified Energized Electrical Employee (Personnel who work within limited approach boundaries of exposed energized conductors and circuit parts)

4.2 Requirements

The ESP defines different qualification categories and associated requirements for electrical safety work practices. The training will consist of standardized classroom training, and on-the-job task-specific training.

The PRO will provide ESP standardized classroom presentations and examination training materials to be used by the facilities. Facilities have the option to hire a contractor to perform the training, but Reclamation's policies and requirements established by this FIST are to be addressed as part of the training.

4.3 Unqualified Employees

An unqualified person does not perform electrical work or O&M on electrical equipment. The duties of these personnel do not involve switching operations to change positions of breakers or disconnect switches for maintenance.

[Training for unqualified employees must include basic electrical safety training annually.]

4.4 Qualified Employees

[A qualified employee must be trained and knowledgeable in the construction and operation of electrical equipment or a specific work method and be trained to identify and avoid the electrical hazards that might occur in connection with that equipment or work method.] A person can be considered qualified with respect to certain equipment and methods, but still be unqualified for others.

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

[Qualified employees must receive:

(1) **Basic electrical safety training at least annually.**

(2) **Qualified electrical worker training every three years.**

(3) **Training upon employment prior to performing any type of electrical work and additional training is required:**

   a. When the employee must use safety-related work practices that are not normally used during their regular job duties.

   b. If a supervisor or annual reviews indicate that the employee is not complying with the safety-related work procedures and practices.

   c. Upon installation of new technology or new types of equipment at the facility.

   d. Whenever new safety-related work practices and procedures are required.]

[Reclamation non-facility personnel must be provided training on the facility's FESP upon arrival at the facility to include any special electrical safety requirements that apply to the scope of work they will be performing.]

4.5 Documentation of Training

Managers are responsible for ensuring all training (including any retraining) is documented in the Department of the Interior's designated learning database. All training is required to have signature confirmation by the employee for completion of training.

5.0 Risk Assessment Considerations for Energized Work

[A documented arc flash and shock risk assessment must be performed to determine if a hazard exists for each task that has been designated in Section 3.0(1)(e).] Section 10 and NFPA 70E Annex "F" should be reviewed for more information.

A risk assessment will use the information in the Arc Flash Hazard Analysis Report as related to the tasks to be performed. If an electrical hazard exists, the risk assessment will include a procedure (see Section 3.1) to carry out the following:

(1) Identify hazards

(2) Assess risks

(3) Implement safety control strategies utilizing the hierarchy of controls identified in Section 5.3.

5.1 Hazard Identification

{This risk assessment must identify the electrical hazards associated with the energized electrical work/task to be performed.}

The Arc Flash Hazard Analysis Report should be referenced to identify potential incident energy exposure.

The shock hazard assessment will determine the voltage to which employees will be exposed, the boundary requirements, and the PPE necessary to minimize the possibility of electrical shock to employees.

5.2 Assessing Risk

For assessing the arc flash hazard risk, Appendix D should be referenced.

For assessing the shock hazard risk and for determining the approach boundaries for AC and DC systems, the Arc Flash Hazard Analysis Report and NFPA 70E Tables 130.4(D)(a) and 130.4(D)(b) should be referenced.

5.3 Safety Control Strategies

Reclamation has adopted ANSI Z-10, a U.S.-Based Consensus Standard for an Occupational Safety and Health Management System. The implementation of

safety control strategies by eliminating hazards or reducing them to an acceptable level is the first step towards meeting Reclamation's commitment to providing a safe workplace and establishing an electrically safe work condition. NFPA 70E, also a nationally recognized consensus standard, employs these control strategies for mitigating, reducing, and eliminating hazards associated with electrical work.

{Control strategies must be considered and documented in descending order of effectiveness to reduce hazards to the maximum extent possible.}
It should be noted that PPE is the last strategy, which provides the least amount of protection, and that it should not be considered until other strategies have been considered and implemented. PPE is the last line of defense for employee safety.

5.3.1 Elimination

De-energizing and establishing an electrically safe work condition is the ideal method of eliminating injuries due to shock or arc flash hazards. By following hazardous energy controls, the risks have been eliminated and the potential inherent electrical hazards have been effectively eliminated. Using FIST 1-1 and Section 6.0, the hazards can be eliminated. It should be noted that the hazard elimination process, e.g. placing the equipment in an electrically safe work condition, could require interaction with energized equipment and the hazards can only be considered eliminated once the electrically safe work condition is established.

5.3.2 Substitution (NFPA 70E Annex "F")

Replacing equipment or changing procedures and processes may effectively eliminate or reduce the hazards to tolerable level of risk or to a lower risk where a combination of controls can be implemented to reduce the risk and potential hazards to the employee.

5.3.3 Engineering Controls (NFPA 70E Annex "O")

(1) Modifying or adding protection controls such as the use of zone selective interlocking;

(2) Replacing older breakers with breakers that have adjustable trip elements;

(3) Differential relaying;

(4) Energy-reducing maintenance switch systems;

(5) Energy-reducing active arc flash mitigation systems;

(6) Arc flash relay;

(7) High-resistance grounding coils; and

(8) Current-limiting devices.

5.3.4 Awareness

The use of warning labels, signs, equipment labeling, and alerting techniques. (NFPA 70E Art. 120, 130.5(D) and 130.7(E))

5.3.5 Administrative Controls (NFPA 70E Ch. 1)

(1) Emergency procedures
(2) Employee training
(3) Risk assessment
(4) Job briefing
(5) Increasing working distances
(6) Reviewing Lockout/tagout procedures
(7) Use of Hazardous Energy Work Permits
(8) Approach boundaries
(9) Arc flash boundaries
(10) Arc Flash Hazard Analysis Report.

5.3.6 PPE (NFPA 70E 130.7(C))

(1) Considered the least effective of the safety controls.
(2) Last line of defense before an event happens.
(3) Properly arc resistance (AR) rated for the exposure.
(4) Most appropriate PPE for the tasks to be performed determined and used.
(5) Adequately maintained and inspected.
(6) Does not protect against hazards such as concussion, flying debris, or foreign objects.

5.3.7 Body Positioning

While it is not a listed safety control strategy, **{body positioning must be considered for energized electrical equipment switching and/or interaction.}** For equipment operation or switching of equipment that has a higher arc flash hazard, a remote operating device is a recommended mitigation tool to increase the working distance. However, the working distance cannot always be increased because of limitations of the equipment, the room layout, or other factors.

A conventional practice has been to stand on the hinged side when performing operations on equipment that has a hinged door or front panel. The theory behind this practice is that the equipment door/panel will provide protection from the heat

energy if it is blown open. In many instances, however, the door/panel becomes an additional hazard, thus contradicting the basis for this conventional practice. The door can cause serious physical damage not only to personnel but to the PPE that they are wearing. This door could be blown open with enough force to knock personnel off their feet or even trap them against a wall or equipment, increasing the time it takes to get away from the heat energy of the arc flash event.

Industry studies and testing have demonstrated that when operating or performing switching on energized equipment, it is recommended to stand opposite the hinged side of equipment. In most cases, even with the switch in the middle of the equipment door, taking this position should reduce the hazard of the door/panel, as the equipment will likely fail with the door/panel being blown off straight forward or swinging around on its hinges. It is also important to have an escape route on the side of the equipment where equipment operation is being performed.

An Incident Energy Analysis can calculate the expected heat energy exposure, and provide PPE recommendations to protect against this energy. However, the Incident Energy Analysis cannot calculate the damage caused by doors/panels that become flying projectiles. Therefore by standing opposite the hinged side of equipment and wearing the appropriate PPE, additional hazards associated with an arc flash event can be reduced. Body positioning must be evaluated and included into the written procedures.

6.0 Establishing an Electrically Safe Work Condition

Establishing an electrically safe work condition is the preferred method for working on electrical equipment or circuit parts. This section should be used when possible.

{An electrically safe work condition must be achieved in accordance with the hazardous energy control procedures identified in FIST 1-1. Establishing an electrically safe work condition will include:

(1) Verification of deenergization using an adequately rated test instrument to test each phase conductor or circuit part to verify it is deenergized. Before and after each test, determine that the test instrument is operating satisfactorily through verification on a known source. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground.}

(2) In some instances in which employees can potentially be exposed to electrical hazards, the use of proximity probes to verify deenergization is

allowed, as long as verification of deenergization of both phase-to-phase and phase-to-ground is conducted prior to contacting conductors. (Note: Deenergization verification is an arc flash hazard.)

(3) If applicable, where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply personal protective grounds in accordance with FIST 5-1, Personal Protective Grounding for Electric Power Facilities and Power Lines. (Note: Installation of personal protective grounds is considered an arc flash hazard.)

6.1 Personal Protective Grounding

The primary purpose of personal protective grounding (PPG) is to provide adequate protection against electrical shock causing death or injury to personnel working on deenergized lines or equipment. This is accomplished by grounding and bonding lines and equipment to limit the body contact or exposure voltages at the worksite to a safe value if the lines or equipment are accidentally energized.

{Only qualified personnel trained on proper PPG selection and installation must install PPGs.} FIST 5-1, Personal Protective Grounding for Electric Power Facilities and Power Lines; FIST 1-1, Hazardous Energy Controls; and the Reclamation Safety and Health Standards (RSHS) Ch. 12 define the requirements to be followed where the possibility of induced voltages or stored electrical energy exists. The system is not to be considered safe to touch until all three phase conductors are effectively grounded.

[A written grounding procedure is required per FIST 5-1 and RSHS Ch. 12 for the placement and removal of PPG. This procedure will document the steps/tasks and the potential hazard for each step/task. The following minimum steps must be included in the procedure:

(1) **Place the equipment into an electrically safe work condition using the appropriate hazardous energy control procedure per FIST 1-1.**

(2) **Ensure that all reclosing capability has been disabled, if applicable, and relay protection is in service.**

(3) **Use the two-person rule to ensure the proper procedures are followed and to double-check locations, etc. Refer to the Incident Energy Analysis or arc flash labeling to determine the selection of the appropriate PPE. (The circuit is still considered energized until grounds are in place, so appropriate shock hazard protection must be used until the grounds are fully applied.)**

If the Arc Flash label indicates >8 cal/cm^2, a risk assessment must be performed to implement safety control strategies to reduce employee exposure to 8 cal/cm^2 or lower as specified in this document. If the Arc Flash label indicates >40 Cal/cm^2, and a unique grounding evaluation is not included in the Arc Flash Hazard Analysis Report or the FESP, a risk assessment must be performed to implement safety control strategies to reduce employee exposure to ≤8 cal/cm^2 or to ≤40 cal/cm^2 following the guidance specified in this document.

(4) **While wearing the appropriate PPE identified, perform a 3-point test with an appropriate sensitive voltage testing device to verify a zero energy state. A 3-point test consists of testing the voltage tester on a known energized source to verify it is working properly (Test No. 1). Then, test the circuit on which work is to be performed (Test No. 2). Finally, test the voltage tester on the same energized source as was used in Test No.1 to verify the tester is still working properly (Test No. 3). Examples of sensitive voltage testing devices include "proximity" testers, tic-tracer, or direct-reading HV voltmeters. This test must be performed for each phase.**

(5) **While wearing the appropriate PPE as determined, after the circuit or exposed conductor has been verified deenergized, using the grounds to be applied, touch or tap the exposed circuit parts to ensure there is no sustained arcing or presence of voltage/current detected.**

(6) **Immediately after verifying deenergization and performing the ground touch test to verify the circuit is indeed deenergized, apply the personal protective grounds using the appropriate live-line tool. A minimum level of 8 cal/cm^2 arc flash clothing and safety PPE is required for the application of PPGs after verifying deenergization.]**

7.0 Interaction with Energized Electrical Equipment

Interaction is affecting or changing the state or condition, or performing work on energized electrical equipment (e.g., breaker operations and racking, operational configuration management, opening cabinet doors and removing covers on energized electrical equipment, etc.).

[The applicable sections of 7.2 must be utilized if a documented evaluation determines that the Normal Operations requirements in section 7.1 are not met.]

7.1 Performing Normal Operations

{An evaluation must be conducted and documented prior to performing normal operations. Specific tasks identified in Appendix D have been determined to be a minimal risk under certain situations.

Any employee exposure to an arc flash hazard with incident energy exposure >40 cal/cm^2 is prohibited.

All of the following conditions must be met to perform Normal Operations:

(1) The equipment is properly installed.

(2) The equipment is properly maintained and documented as required by the applicable FIST manuals and Power Equipment Bulletins (PEBs). If the equipment is not identified in the Reclamation FIST manuals or PEBs, then appropriate maintenance meeting the manufacturer recommendations, NFPA 70B and NFPA 70E, inclusive, must be accomplished and documented as the maintenance program.

(3) The equipment doors are closed and properly secured.

(4) All of the equipment covers are in place and properly secured.

(5) There is no evidence of damage, overheating, or impending failure.

(6) There is no increased risk of an arc flash hazard.

(7) All protection devices, protective relays, and trip elements protecting the equipment or device have been properly maintained, tested and documented within the FIST-required time intervals.

(8) Proper configuration management of the protection systems has been verified, where applicable.}

7.2 Interacting with or Working on Energized Electrical Equipment

{At least two employees shall be present when performing the following types of work:

(1) Installation, removal, or repair of lines energized at more than 600 volts,

(2) Installation, removal, or repair of deenergized lines if an employee is exposed to contact with other parts energized at more than 600 volts,

(3) Installation, removal, or repair of equipment, such as transformers, capacitors, and regulators, if an employee is exposed to contact with parts energized at more than 600 volts,

(4) Work involving the use of mechanical equipment, other than insulated aerial lifts, near parts energized at more than 600 volts, and

(5) Other work that exposes an employee to electrical hazards greater than, or equal to, the electrical hazards posed by operations listed above.}

{Exceptions to the two-person rule are allowed when the requirements of section 7.1 are met, risk assessments have been performed, and procedures have been developed for the following situations:

(1) Normal operations, when conditions at the site allow safe performance of this work,

(2) Work performed with live-line tools when the position of the employee is such that he or she is neither within reach of, nor otherwise exposed to contact with, energized parts, and

(3) Emergency repairs to the extent necessary to safeguard the general public.}

{When interacting with or working on energized equipment that does not meet the requirements of section 7.1, an HEWP must be established.} Requirements for the HEWP are defined in FIST 1-1. Where a conflict exists between documents, the most restrictive will apply. Exceptions to the HEWP are defined in FIST 1-1. **{An HEWP must be used when energized work is performed under this section, and under either of the following conditions:**

(1) When work is performed within the restricted approach boundary identified in the shock risk assessment.

(2) When the employee interacts with energized electrical equipment or performs tasks not identified in Appendix D, when conductors or circuit parts are not exposed, but an increased likelihood of injury from an arc flash hazard exists.}

8.0 Equipment Labeling and Approach Boundaries

8.1 Equipment Labeling

Equipment warning labels are a mitigation technique to alert employees that the equipment presents serious electrical safety hazards and that special precautions are required prior to interacting with or working on the equipment.

An Arc Flash Hazard Analysis Report (Section 10.0) or a task-based assessment without an Incident Energy Analysis is necessary to provide the information contained on the label and for the information required by NFPA 70E, Article 130.5(D).

{The method of calculation and data to support the information for the label must be documented. Electrical equipment such as switchgear, switchboards, panel boards, industrial control panels, breaker panels, meter socket enclosures, and motor control centers that are likely to require operation, examination, adjustment, servicing, or maintenance while energized must be field-marked with a label containing the following information:

(1) At least one of the following:

(a) Available incident energy and the corresponding working distance.

(b) Minimum arc rating of clothing.

(c) Required level of PPE.

(d) Highest Hazard/Risk Category for the equipment (if an Incident Energy Analysis was not performed).

(2) Nominal system voltage.

(3) Arc flash boundary.

(4) Shock hazard boundaries.}

8.2 Approach Boundaries

{Boundaries must be established when an arc flash hazard or a shock hazard are present.} Refer to NFPA 70E 130.4(B) for shock protection boundary and 130.5(B) for arc flash protection boundary requirements. The minimum arc flash boundary is 3 feet and any arc flash boundary that is less than 3 feet should be rounded up to the minimum value. Any arc flash boundary greater than 3 feet should be rounded up to the next whole foot.

Boundary markers and barricades clearly identify the arc flash hazard and the shock hazard boundary. The use of barricades and barriers will provide a warning to personnel and limit access, as well as provide a physical obstruction to prevent contact with equipment or energized electrical conductors and circuit parts to prevent unauthorized access to a work area. These may be of the retractable belt barrier type, safety tape, panels or of a similar nature. Painted lines on the floor, by themselves, are not adequate. If painted lines on the floor are used, a spotter, who is not involved in the work being performed and who is physically positioned outside of the arc flash boundary is required. Arc flash hazard boundary and shock hazard boundaries are only applicable when the hazard exists.

The arc flash hazard analysis must be referred to when determining the distances for the boundaries. In the absence of an arc flash study, the tables in NFPA 70E must be utilized until an arc flash study is completed.

Various methods to mark the arc flash boundaries are shown in the photos below.

Figure 1. Marking arc flash hazard boundaries.

9.0 PPE and Clothing

PPE will include protective clothing and equipment to protect personnel from exposure to arc flash hazards and shock hazards identified by the risk analysis. PPE requirements are defined in NFPA 70E 130.7(C) or Annex H.3(b).

9.1 Standard Work Clothing

{All employees within the arc flash protection boundary, regardless of work being performed, must wear non-melting, untreated, natural fiber standard work clothing, including undergarments as a base to the appropriate PPE, to protect the body from severe injury from an arc flash. Synthetic clothing must not be worn because it could ignite and be trapped between the employee's skin and the PPE.} Furthermore, when synthetic clothing burns, it can melt into the skin and can aggravate a burn injury.

Employees are responsible for providing their own standard work clothing.

9.2 Arc Rated (AR) Clothing and PPE

{Reclamation must provide the appropriate PPE for the task to be completed.}

AR clothing is a form of PPE. AR clothing worn daily as work clothing and not properly cared for and evaluated prior to use might not provide the adequate protection as PPE. Using AR clothing as regular work clothing could result in contamination of the clothing and defeat the protection characteristics.

{All employees working within an arc flash boundary where electrical hazards are present must be provided with, and must use PPE clothing that is designed and constructed for the specific part(s) of the body to be protected and for the work to be performed.}

{All AR PPE clothing worn within the arc flash boundary must meet the requirements of ASTM F1506 and have the appropriate Arc Thermal Protection Value (ATPV) rating (in cal/cm^2) listed on the label.}

{When AR PPE clothing is required, it must cover the entire body, including all standard clothing, and must allow for movement and visibility.}

9.3 Care and Maintenance of AR Clothing and AR Flash Suits

{AR clothing and arc flash suits must be inspected before each use. Those found to be damaged must not be used. Protective items that become contaminated with grease, oil, or flammable or combustible materials must not be used and must be cleaned immediately. AR clothing must be cleaned and maintained as specified by the clothing manufacturer. Cleaning of AR clothing, if performed according to manufacturer's requirements, has been shown to be very effective in removing contaminants and returning the garments to near original condition.}

When AR clothing is repaired, use the same AR materials used to manufacture the AR clothing. When affixing trim, name tags, logos, or any combination thereof to AR clothing, use AR material.

9.4 Shock Protective Equipment and Clothing

Employees working within the shock protection boundaries must wear the appropriate shock PPE, according to the shock protection boundary crossed, in addition to AR clothing.

{Conductive articles of jewelry and clothing (such as watchbands, belt buckles, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) must not be worn as they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.}

Refer to NFPA 70E Annex H.3(a) for help in determining the proper shock hazard PPE.

10.0 Arc Flash Hazard Analysis

Once the Arc Flash Hazard Analysis Report is received from the qualified engineer performing the study, the findings should be reviewed for accuracy. **[Recommendations identified to reduce the hazards to levels described in the Arc Flash Hazard Analysis Report must be entered into PRIS or the agency's applicable recommendations tracking system and be implemented.]** Where conflicts exist between the report and the facility staff, they will be mutually resolved, and the Arc Flash Hazard Analysis Report updated accordingly.

10.1 Incident Energy Analysis

Performing an Incident Energy Analysis is an integral part of an Arc Flash Hazard Analysis Report (See Section 10.5). The Incident Energy Analysis determines the severity of potential arc flash hazards by identifying the arc flash boundary, the incident energy at the minimum working distance, and the required PPE to be used within an arc flash boundary. This analysis provides the information and tools that can be used to reduce the potential incident energy exposure. **{Qualified engineers (Section 10.2) must conduct the Incident Energy Analysis.}**

{An Incident Energy Analysis must be performed in accordance with the published calculations and recommendations in IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*, or other applicable standards.}

An Incident Energy Analysis is required for:

- Powerhouses;
- Dams and spillways;
- Fish facilities;
- Pumping stations, irrigation, and domestic water facilities;
- Maintenance shops, laboratories, or similar type facilities.

Upon evaluation of these facilities, a qualified engineer may determine that an Incident Energy Analysis is not practical or necessary, and recommend that the task based NFPA 70E tables be used for PPE selection for facilities where all equipment locations are outside the scope of the available incident energy calculation methods in IEEE 1584.

The Incident Energy Analysis involves studying the electrical characteristics, equipment construction/condition, operating configurations, protective devices, and physical location of each circuit in the scope of the analysis. **[The assumptions, calculations, methodology, findings, and recommendations made while performing the Incident Energy Analysis of these circuits must be documented in the facility Arc Flash Hazard Analysis Report. The Incident Energy Analysis must be performed in tandem with an equipment duty evaluation and a protective device coordination study.]**

[The Arc Flash Hazard Analysis Report must be updated when a major modification or renovation takes place, including external system/utility changes. The Arc Flash Hazard Analysis Report must be reviewed at least once every 5 years by a qualified engineer, to account for changes in the electrical systems that could affect the results of the analysis, updated arc flash hazard information or guidance, and revised industry standards.]

10.2 Qualified Engineer

A qualified engineer has intimate knowledge and experience in performing power system and Incident Energy Analysis. [**A qualified engineer must be routinely involved with performing arc flash hazard analyses, fault calculations, protective device coordination, power equipment analysis, and transient machine dynamics for electrical systems and subsystems commonly found in federal, commercial, and industrial facilities that are associated with the management, administration, and operation of hydroelectric powerplants, other water conveyance structures, or Reclamation office buildings, warehouses, and other similar types of facilities. The engineer must perform these duties full time, not infrequently as a collateral duty, to be designated as qualified and to maintain proficiency in this rapidly changing field of expertise. A qualified engineer must have a professional engineer license and have detailed training, experience, and intimate knowledge of the subject matter that they are technically conducting, approving, and peer reviewing.**]

The TSC engineers who perform and peer review the Incident Energy Analysis are very specialized within their discipline and are required to hold a professional registration (Professional Engineer) license. They perform the functions of a qualified engineer full-time, are continually and actively involved in developing industry standards and practices, and are best suited to guide Reclamation in this subject. The TSC should be considered the primary source for providing Incident Energy Analysis for Reclamation power and pumping facilities. Other sources may be utilized when TSC cannot complete the studies during the specified timeframes.

Regional and area office employees, engineering firms, or other government agencies may also be able to complete the Incident Energy Analysis. [**If regional or area office employees, engineering firms, or other government agencies are to be used, they must provide personnel who meet this document's definition of a qualified engineer.]** Persons performing analysis are required to have similar experience with generation, heavy industry, electrical system studies, and low- to high-voltage equipment.

[The Incident Energy Analysis must be peer reviewed by a qualified engineer who was not involved in performing the original analysis.]

10.3 Task-Based Assessment without an Incident Energy Analysis

{If an Incident Energy Analysis has not been performed, and it becomes necessary to perform work on energized parts, then the NFPA 70E tables must be used as a temporary interim step until an Incident Energy Analysis can be completed.}

[Facilities that are required to have an Incident Energy Analysis performed and are implementing an interim task-based assessment must have the assessment reviewed by a TSC qualified engineer as specified by Section 10.2. The scheduled completion date for the Incident Energy Analysis must be documented within the task-based assessment.]

It is very important to keep in mind that the task-based tables listed in NFPA 70E have specific limitations and include assumptions that may not adequately protect a worker from an arc flash hazard. They may also direct workers to wear more PPE than is required. However, using the task-based tables in NFPA 70E is a much better alternative than having no guidance at all. [**If the task-based tables are used, a facility task-based risk assessment must be performed and procedures must be developed as specified in Section 3.1.]**

[Personnel performing a task-based assessment must follow and document the following steps when performing a task-based assessment:

(1) **Review this FIST and the RSHS for equipment evaluation methodologies.**

(2) **Identify all locations and equipment in the facility that pose an arc flash hazard.**

(3) **List the equipment and/or locations for which the flash protection boundary can be determined by the applicable NFPA 70E tables.**

(4) **Determine tentative flash protection boundaries and PPE requirements for all pertinent equipment using the applicable NFPA 70E tables.**

(5) **Document the results of the task-based assessment based upon the applicable NFPA 70E tables.**

(6) **Mitigate known arc flash hazards using the safety control strategies to the extent possible.**

(7) **Fulfill all requirements that would apply if an Incident Energy Analysis had been completed. The task-based hazard risk categories will be treated the same as if the incident energy calculations were completed.]**

The task-based assessment may be used in lieu of an Incident Energy Analysis at offices, recreational areas, remote communication sites, or similar type facilities where an Incident Energy Analysis has not been performed. Since the task-based tables listed in the NFPA 70E have limitations of task types, assumed maximum short-circuit currents, and assumed maximum fault clearing times, **[the task-based risk assessment must be reviewed by a qualified engineer.]**

10.4 Arc Flash Hazard Analysis Scheduling

An Arc Flash Hazard Analysis for a facility should be scheduled far enough ahead to ensure that the analysis can be performed within a desired timeframe and that it is kept up to date within the 5-year review requirement.

It is recommended that Arc Flash Hazard Analyses be scheduled at least 1 year in advance of the 5-year review requirement. As significant effort and time is required to perform an Arc Flash Hazard Analysis, sufficient time needs to be accounted for in scheduling data collection site visits, completing the analysis, and providing the facility opportunity to implement the analysis results. Note that the Technical Service Center performs Arc Flash Hazard Analyses on a first come, first served basis.

Scheduling an Arc Flash Hazard Analysis to be performed just before a major equipment modification or replacement is not recommended, as this will invalidate the analysis results and require a new one to be performed. If equipment is scheduled to be replaced around the same time when a 5-year update to the Arc Flash Hazard Analysis is required, options are available to provide or maintain adequate protection for personnel until the equipment is replaced and Incident Energy Analysis is updated. Please contact the Power System Analysis & Controls Group at the Technical Service Center for additional information and options to address issues on this matter.

10.5 The Arc Flash Hazard Analysis Report

The development and documentation of Arc Flash Hazard Analysis reports ideally should be consistent across Reclamation facilities. **[The report must contain the elements identified in IEEE Standard 1584. If an outside contractor is hired to perform the analysis, the specification for the contract must identify the elements that should be addressed in the report. IEEE 1584.1-2013*, IEEE Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584*, must be referenced when developing the specification for work to be performed.]**

[The specification must include the minimum elements for the Arc Flash Hazard Analysis Report as identified in IEEE 1584.1-2013 Sect. 10. The specification must also contain the requirements to mitigate the hazards to meet Reclamation's personnel exposure goals as identified in this FIST and in accordance with the mitigation techniques identified in ANSI/AIHA Z-10.]

[The recommendations from the Arc Flash Hazard Analysis Report must be entered into the applicable recommendation tracking system. When the analysis is performed by non-Reclamation personnel, the recommendations for the Power Program must be evaluated and aligned to the requirements established by FAC 04-02 and entered into the applicable recommendation tracking system.]

Appendix A – References

Industry Standards

29 Code of Federal Regulation (CFR) 1910.147, *The Control of Hazardous Energy Sources (Lockout/Tagout).*

29 CFR 1910.269 (l) (6), *Electric Power Generation, Transmission, and Distribution.*

American National Standards Institute (ANSI) Z10, *American National Standard for Occupational Health and Safety Management Systems*.

ANSI Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*.

American Society for Testing and Materials (ASTM) International F1506-08, *Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards*.

Institute of Electrical and Electronics Engineers Standard 1584A, *Guide for Performing Arc Flash Calculations.*

National Fire Protection Association (NFPA) 70, *National Electric Code*.

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.

NFPA 70E, *Standard for Electrical Safety in the Workplace*.

Occupational Safety and Health Administration Standards 29 CFR, Part 1910.333.

IEEE 1584.1-2013, *IEEE Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584.*

IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*.

Reclamation Standards

Reclamation Safety and Health Standards.

FIST 1-1, *Hazardous Energy Control Program.*

FIST 5-1, *Personal Protective Grounding for Electric Power Facilities and Power Lines*.

Appendix B – Definitions

Approved. Acceptable to the authority having jurisdiction.

Arc Flash Hazard. A dangerous condition associated with the possible release of energy caused by an electric arc.

Informational Note No. 1: An arc flash hazard may exist when energized electrical conductors or circuit parts are exposed or even when they are guarded or enclosed within equipment, provided a person is interacting with the equipment in such a manner that could cause an electric arc. Under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard.

Informational Note No. 2: See NFPA 70E Table 130.7(C)(15)(A)(a)and Appendix E for examples of activities that could pose an arc flash hazard.

Arc Flash Hazard Analysis Report. A report performed for a specific facility, which will likely contain the following information: General Arc Flash Hazard Background and Information, Recommendations, Study Methodology, Incident Energy Analysis, Arc Flash Hazard Results, Protective Device Coordination, Equipment Duty Evaluation, and Arc Flash Labeling Guide

Arc Flash Suit. A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet.

Informational Note: An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating. The value, attributed to materials, which describes their performance when exposed to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined arc thermal performance value (ATPV) or the energy of break-open threshold (EBT) (should a material system exhibit a break-open response below the ATPV value). Arc rating is reported as either the ATPV or the EBT, whichever is the lower value.

Informational Note No. 1: Arc-rated clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame resistant clothing without an arc rating has not been tested for exposure to an electric arc. All arc-rated clothing is also flame-resistant.

Informational Note No. 2: Break-open is a material response evidenced by the formation of one or more holes in the innermost layer of arc-rated material that would allow flame to pass through the material.

Informational Note No. 3: ATPV is defined in ASTM F1959/F1959M, Standard Test Method for Determining the Arc Rating of Materials for Clothing, as the incident energy (cal/cm^2) on a material or a multilayer

system of materials that results in a 50-percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve.

Informational Note No. 4: EBT is defined in ASTM F1959/F1959M, Standard Test Method for Determining the Arc Rating of Materials for Clothing, as the incident energy (cal/cm^2) on a material or a material system that results in a 50-percent probability of break-open. Break-open is defined as a hole with an area of 1.6 cm^2 (0.5 in^2) or an opening of 2.5 cm (1.0 in.) in any dimension.

Automatic. Performing a function without the necessity of human intervention.

Barricade. A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.

Barrier. A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts or to prevent unauthorized access to a work area.

Boundary, Arc Flash. When an arc flash hazard exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur. The minimum Arc Flash Boundary is 3 feet. Any Arc Flash Boundary identified in the incident energy analysis as being less than 3 feet must be rounded up to this minimum value. Any Arc Flash Boundary greater than 3 feet should be rounded to the next whole foot.

Informational Note: A second degree burn is possible from an exposure of unprotected skin to an electric arc flash above the incident energy level of 5 J/cm^2 (1.2 cal/cm^2).

Boundary, Limited Approach. An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

Boundary, Restricted Approach. An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit part.

Cabinet. An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.

Circuit Breaker. A device designed to open and close a circuit by manual operation and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Informational Note: The automatic opening means can be integral, direct acting with the circuit breaker, or remote from the circuit breaker.

Conductor, Bare. A conductor having no covering or electrical insulation whatsoever.

Current-Limiting Protective Device. A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Deenergized. Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Device. A unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function.

Disconnect (or Isolating) Switch. A mechanical switching device used for isolating a circuit or equipment from a source of power.

Electrical Hazard. A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.

Informational Note: Class 2 power supplies, listed low voltage lighting systems, and similar sources are examples of circuits or systems that are not considered an electrical hazard.

Electrical Safety. Recognizing hazards associated with the use of electrical energy and taking precautions so that hazards do not cause injury or death.

Electrically Safe Work Condition. A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.

Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized electrical conductors or circuit parts or to protect the equipment from physical damage.

Energized. Electrically connected to, or being, a source of voltage.

Equipment. A general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like, used as a part of, or in connection with, an electrical installation.

Exposed (as applied to energized electrical conductors or circuit parts). Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

FESP. Facility Electrical Safety Program. The FESP is an overall program in which:

1) The facility-specific hazards are identified,

2) Tasks that require interaction or work on energized electrical equipment are identified,
3) An Incident Energy Analysis is performed at the facility,
4) Safety control strategies are developed to mitigate the potential hazards that may threaten employee interacting with or working on energized electrical equipment.
5) Hazardous Energy Work Permits (HEWPs) are utilized,
6) The documentation described above is compiled and retained to be used as a reference.

Ground. The earth, or a conductor that makes an electrical connection to the earth.

Ground Fault. An unintentional, electrically conducting connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.

Grounded (Grounding). Connected (connecting) to ground or to a conductive body that extends the ground connection.

Ground-Fault Circuit Interrupter. A device intended for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.

Informational Note: Class A ground-fault circuit interrupters trip when the current to ground is 6 mA or higher and do not trip when the current to ground is less than 4 mA. For further information, see ANSI/UL 943, Standard for Ground-Fault Circuit Interrupters.

Grounding Conductor, Equipment. A conductor that provides a ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.

Informational Note No. 1: It is recognized that the equipment grounding conductor also performs bonding.

Informational Note No. 2: See 250.118 of NFPA 70, National Electrical Code, for a list of acceptable equipment grounding conductors.

Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

Hazard. A source of possible injury or damage to health.

Hazardous. Involving exposure to at least one hazard.

Increased Risk. An increased risk occurs when a qualified employee interacts with equipment in a manner that increases the likelihood of injury from

exposure to an arc flash incident, such as racking equipment in or out, or when opening doors or covers that expose energized conductors or circuit parts. The risk should be evaluated based on the incident energy findings in the shock risk assessment and the arc flash risk assessments.

Incident Energy. The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. Incident energy is typically expressed in calories per square centimeter (cal/cm^2).

Incident Energy Analysis. A component of the Arc Flash Hazard Analysis Report used to predict the incident energy of an arc flash for a specified set of conditions.

Insulated. Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

Informational Note: When an object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subject. Otherwise, it is, within the purpose of these rules, uninsulated.

Interacting. Affecting or changing the state or condition, or performing work on, other than "Normal Operation" (as defined in this document, when all of the listed conditions are met). Interacting increases the risk of a potential hazard.

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

Motor Control Center. An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Operational Configuration Management. A type of management performed by changing the position and status of electrical, mechanical, hydraulic, etc., systems and devices.

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

Informational Note: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.

Qualified Person. One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved.

Reclamation Non-Facility Personnel: Any Reclamation personnel who are not authorized employees at the facility. Examples would include the Technical Service Center, dive teams, rope teams, regional personnel, etc.

Risk. A combination of the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard.

Risk Assessment. A risk assessment is an overall process that identifies the hazards using the results of an Incident Energy Analysis or shock hazard analysis, estimates the potential severity of injury or damage to health, estimates the likelihood of occurrence of injury or damage to health, and determines the appropriate procedures to be followed, safety control and mitigation strategies, and what protective measures are required.

Informational Note: As used in this standard, arc flash risk assessment and shock risk assessment are types of risk assessments.

Shock Hazard. A dangerous condition associated with the possible release of energy caused by contact or approach to energized electrical conductors or circuit parts.

Switchboard. A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. These assemblies are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets.

Switchgear, Arc-Resistant. Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.

Switchgear, Metal-Enclosed. A switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows), containing primary power circuit switching, interrupting devices, or both, with buses and connections. This assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both. Metal-enclosed switchgear is available in non-arc-resistant or arc-resistant constructions.

Unqualified Person. A person who is not a qualified person.

Voltage (of a Circuit). The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Informational Note: Some systems, such as three-phase 4-wire, single-phase 3-wire, and 3-wire direct-current, may have various circuits of various voltages.

Voltage, Nominal. A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts).

Informational Note No. 1: The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Informational Note No. 2: See ANSI C84.1, Electric Power Systems and Equipment — Voltage Ratings (60 Hz).

Working Distance. The dimension between the possible arc point and the head and body of the worker positioned in place to perform the assigned task.

Working On (energized electrical conductors or circuit parts). Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the PPE a person is wearing. There are two categories of "working on": Diagnostic work (testing) is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; repair is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.).

Appendix C – Training Proficiency Sheets

Basic Electrical Safety Training
Proficiency Sheet

Explain or Demonstrate Proficiency	YES	NO
1. Explain the consequences of violating Electrical Safety requirements.	☐	☐
2. Explain the relationship between exposure to potential electrical hazards and possible bodily injury.	☐	☐
3. Demonstrate how to identify electrical equipment.	☐	☐
4. Demonstrate how to identify exposed electrical equipment and components.	☐	☐
5. Explain what actions need to be taken before drilling into electrical panels, equipment or concrete.	☐	☐
6. Explain precautions to be taken when operating vehicles or working in the vicinity of overhead lines.	☐	☐
7. Explain the use of portable electric tools and what inspections should be performed.	☐	☐
8. Explain how to protect electrical cords from damage.	☐	☐
9. Explain why the ground terminal on a plug is important.	☐	☐
10. Explain why and where Ground Fault Circuit Interrupters should be used.	☐	☐
11. Explain the precautions that should be taken when using portable ladders.	☐	☐
12. Explain the precautions that should be taken when working in wet locations.	☐	☐
13. Explain the actions to be taken if damaged electrical equipment or devices are found.	☐	☐
14. Explain how to identify equipment that may have impending failure.	☐	☐
15. Explain what work can be performed by an unqualified worker.	☐	☐

Comments

Overall Grade ☐ Pass ☐ Fail

Plant Supervisor or Examiner / Title _____

_____ _____

Print Name **Signature / Date**

_____ _____ _____

Individual/Title Date **Print Name** **Signature**

Qualified Maintenance Worker ≤600 Volt Nominal
Proficiency Sheet

Explain or Demonstrate Proficiency	YES	NO
1. Completion of Basic Electrical Safety training.	☐	☐
2. Define an electrically safe work condition.	☐	☐
3. Demonstrate the ability to follow safe work procedures and policies.	☐	☐
4. Demonstrate the ability to determine hazardous energy isolation boundaries.	☐	☐
5. Demonstrate the ability to read and understand arc flash labels.	☐	☐
6. Demonstrate the ability to determine proper safety requirements for arc flash in the absence of labels or an Incident Energy Analysis.	☐	☐
7. Utilize safe work practices for the equipment to be operated.	☐	☐
8. Determine appropriate PPE for the associated hazards.	☐	☐
9. Demonstrate proper use of PPE.	☐	☐
10. Demonstrate proper inspection, care, and maintenance of PPE.	☐	☐
11. Demonstrate proper switching techniques and body positioning.	☐	☐
12. Demonstrate the ability to determine appropriate voltage rated test equipment and how to use the device to verify absence of voltage, including interpreting indications provided by the device to verify the equipment is properly deenergized.	☐	☐
13. Completion of first aid training and CPR certification.	☐	☐
14. Qualified as Authorized employee under FIST 1-1, Hazardous Energy Control Program.	☐	☐
15. Explain the PPE requirements necessary when verifying equipment deenergized.	☐	☐
Comments		

Overall Grade ☐ Pass ☐ Fail

Plant Supervisor or Examiner / Title _____

_____ _____
Print Name **Signature / Date**

_____ _____ _____
Individual/Title **Print Name** **Signature / Date**

Qualified High-Voltage Switchman >600 Volt Nominal Proficiency Sheet

Explain or Demonstrate Proficiency		YES	NO
(1)	Completion of Basic Electrical Safety training.	☐	☐
(2)	Completion of Qualified Maintenance Worker: ≤600 volt nominal.	☐	☐
(3)	Qualified as a switchman under FIST 1-1, Hazardous Energy Control Program.	☐	☐
(4)	Demonstrate safe switching techniques for high voltage equipment.	☐	☐
(5)	Explain importance of deenergization prior to operating ground switches.	☐	☐
(6)	Explain the importance of performing switching operations in the sequence listed on the switching program form.	☐	☐
(7)	Explain the importance of grounding pads in switchyards.	☐	☐
(8)	Explain when the use of personal protective grounds are required.	☐	☐
(9)	Demonstrate familiarity with and operations of various types of equipment.	☐	☐
Comments			

Overall Grade ☐ Pass ☐ Fail

Plant Supervisor or Examiner / Title _____

_____ _____

Print Name **Signature / Date**

_____ _____ _____

Individual/Title **Print Name** **Signature / Date**

Qualified Heavy Equipment Operator Electrical Safety Proficiency Sheet

Explain or Demonstrate Proficiency	YES	NO
1. Completion of Basic Electrical Safety training.	☐	☐
2. Explain the requirements for working around overhead lines (OSHA 1926.1408, 1409, 1410, 1411, and 1430(a)).	☐	☐
3. Explain precautions for operating equipment near radio and microwave transmission towers.	☐	☐
4. Explain the necessary precautions prior to digging, drilling, or trenching, and the development of a JHA.	☐	☐
5. Define an electrically safe work condition.	☐	☐
6. Demonstrate the use of safe work procedures and policies.	☐	☐
7. Explain the requirements for moving equipment under overhead lines.	☐	☐
8. Explain grounding requirements for mobile equipment.	☐	☐
Comments		

Overall Grade ☐ Pass ☐ Fail

Plant Supervisor or Examiner / Title _____

_____ _____

Print Name **Signature / Date**

_____ _____ _____

Individual/Title **Print Name** **Signature / Date**

Qualified Energized Electrical Worker Proficiency Sheet

Explain or Demonstrate Proficiency		YES	NO
(1)	**Completion of Basic Electrical Safety Training.**	☐	☐
(2)	**Completion of Qualified Maintenance Worker: ≤600 volt nominal.**	☐	☐
(3)	**Completion of Qualified High Voltage Switchman/Worker: >600 volt nominal.**	☐	☐
(4)	**Explain the risks involved with performing energized electrical work.**	☐	☐
(5)	**Explain the various methods of safety controls that can be used to mitigate and reduce hazards.**	☐	☐
(6)	**Demonstrate the requirements for establishing the arc flash boundaries and shock hazard boundaries.**	☐	☐
(7)	**Describe the proper selection of personal protective clothing for the assigned tasks.**	☐	☐
(8)	**Demonstrate the technique for testing voltage-rated gloves prior to use.**	☐	☐
(9)	**Demonstrate the HEWP procedure.**	☐	☐
(10)	**Develop a JHA or a written procedure for performing energized electrical work.**	☐	☐
(11)	**Demonstrate understanding of the degree and extent of the hazards present and the required PPE to use.**	☐	☐
(12)	**Demonstrate the capability to:**		
	(a) Perform the task safely;	☐	☐
	(b) Develop, review, and utilize procedures and proper sequence of work;	☐	☐
	(c) Identify hazards and severity;	☐	☐
	(d) Determine required personnel including first responders;	☐	☐
	(e) Ensure first aid and defibrillator on hand;	☐	☐
	(f) Determine appropriate arc flash and shock hazard PPE;	☐	☐
	(g) Determine required test equipment, including voltage measuring, multimeters, etc;	☐	☐
	(h) Determine additional equipment, parts, tools, etc.	☐	☐

Comments

Overall Grade ☐ Pass ☐ Fail

Plant Supervisor or Examiner / Title _____

_____ _____

Print Name **Signature / Date**

_____ _____ _____

Individual/Title **Print Name** **Signature / Date**

Appendix D – Arc Flash Task List Exceptions

The tasks below have been determined to be a minimal risk to employees if the requirements established in Section 7.1, Normal Operations Exceptions, are met and the identified equipment condition is properly completed and documented.

Task	Equipment Condition
Reading a panel meter while operating a switch.	Any
Operation of control switches or devices that do not pose a shock hazard or have the potential to expose any live circuits, and have an incident energy exposure ≤ 1.2 cal/cm^2, as indicated by Incident Energy Analysis.	Any
Normal operation of a circuit breaker, switch, contactor, or starter. Ground switches are not included in this section.	All of the following: 1. The equipment is properly installed, 2. The equipment is properly maintained, 3. All equipment doors are closed and secured, 4. All equipment covers are in place and secured, 5. There is no evidence of impending failure, 6. There is no increased risk of an arc flash hazard, 7. All protection devices, protective relays and trip elements protecting the equipment or device have been properly maintained and tested within the required time intervals, 8. The protection systems have been verified to be in the proper configuration, where applicable, and 9. A procedure is established for documenting these requirements.
Hand and portable cord and plug connected equipment, single phase and 240v or less.	1. The equipment shows no signs of damage, and 2. Contains a grounding conductor connected to the equipment frame and to a good ground, or 3. Is double-insulated, or 4. Is connected to the power supply through an isolating transformer with an ungrounded secondary of not more than 50 volts.
Voltage testing on individual battery cells or individual multi-cell units.	All of the following: 1. The equipment is properly installed, 2. The equipment is properly maintained, 3. Covers for all other equipment are in place and secured, and 4. There is no evidence of impending failure.

Task	Equipment Condition
Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare energized electrical conductors and circuit parts.	All of the following: 1. The equipment is properly installed, 2. The equipment is properly maintained, and 3. There is no evidence of impending failure.
Removal of battery intercell connector covers.	All of the following: 1. The equipment is properly installed, 2. The equipment is properly maintained, 3. Covers for all other equipment are in place and secured, and 4. There is no evidence of impending failure
Perform infrared thermography and other noncontact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.	Any
Work on control circuits with exposed energized electrical conductors and circuit parts, 120 volts or below without any other exposed energized equipment over 120 V including opening of hinged covers to gain access.	Any
Insulated cable examination with no manipulation of cable.	Any
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack.	Any
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.	Any
Arc-resistant switchgear Type 1 or 2 (for clearing times of <0.5 sec with a prospective fault current not to exceed the arc-resistant rating of the equipment) and metal-enclosed interrupter switchgear, fused or unfused of arc resistant type construction, tested in accordance with IEEE C37.20.7: •Insertion or removal (racking) of CBs from cubicles. •Insertion or removal (racking) of ground and test device. •Insertion or removal (racking) of voltage transformers on or off the bus.	All of the following: 1. The equipment is properly installed, 2. The equipment is properly maintained, 3. All equipment doors are closed and secured, 4. All equipment covers are in place and secured, 5. There is no evidence of impending failure, 6. There is no increased risk of an arc flash hazard, 7. All protection devices, protective relays and trip elements protecting the equipment or device have been properly maintained and tested within the required time intervals, 8. Verification of configuration management of the protection systems has been verified in proper configuration, where applicable, and 9. A documented procedure is established documenting these requirements.

Appendix E – Electrical Safety Program Review Job Plan

Reference: FIST 5-14, FIST 4-1B, and FIST 1-1

(1) Training Records.

(a) A copy of the training records for the ESP should be used to verify that all qualified electrical workers have been trained during the applicable calendar year. Training records should be used to verify the Qualified Employee Authorization List.

(b) Verify that the Department of the Interior designated learning database (currently DOI Learn) has been updated.

(2) Arc Flash Hazard Analysis Report.

(a) An inventory and documentation of equipment that requires interaction by employees where the employees' exposure levels exceed the Reclamation goal and cannot be reduced to meet the goal,

(b) Completion of Risk Assessments and development of procedures to ensure proper compliance with the program and implementation of safety control strategies to reduce employee exposure levels to the maximum extent possible,

(c) Documentation in the Power Review Information System (PRIS) or the agency's applicable recommendation tracking system (e.g., DSIS), of long-range corrective actions being taken to implement the safety control strategies identified in the mitigation techniques that require long-range planning.

(i) Has an Arc Flash Hazard Analysis Report been performed within the last five years or is one scheduled for completion?

(ii) Has any equipment been replaced or modified that would require revision of the study?

(iii) Has all electrical equipment been labeled as required, based on the current Arc Flash Hazard Analysis Report?

(iv) Are all of the labels legible and clearly visible? If not, submit work order to replace the labels.

(v) Have recommendations identified in the arc flash hazard analysis been entered into PRIS or the applicable recommendation tracking system ?

(3) Arc Flash Program Implementation.

(a) Documented control strategy implementation.

(b) Documented procedures for interacting with electrical equipment.

(c) Employee training.

(4) Personal Protective Equipment (PPE).

(a) Review the facility PPE work orders to verify that all shotguns, hot sticks, rubber gloves, voltage testers, test equipment, personal protective ground testers, ramp testing equipment, arc-rated fall protection, etc., have an implemented maintenance program established.

(b) Review the work order(s) to verify that individual PPE has been maintained.

(5) Job Hazard Analysis and Procedures.

(a) Does the facility have detailed identification of hazards and all necessary PPE?

(b) Are the procedures in accordance with FIST 5-14?

(c) Are risk assessments up-to-date, and do they reflect current maintenance?

(d) Have the risk assessments been reviewed annually?

(6) Conduct Employee Interviews.

(a) Evaluate effectiveness of the programs, training, procedures, responsibilities, knowledge, etc.

(b) Note the interview questions and the personnel interviewed in the attached documentation.

(c) List any suggested improvements to the program such as the presentation, examinations, etc.

(d) List any suggested improvements to the training, such as corrections to the presentation or clarifications and additions that would be helpful, etc.

(e) Identify any examination questions that should be reviewed, such as ones that many people misunderstood or missed, or that are not clear. Suggest additional examination questions to be considered.

(f) Review the facility specific examination questions for changes.

(g) Verify that all PPE is utilized properly.

(7) Program Deficiencies. List all deficiencies and the associated corrective action plans.

(a) List all deficiencies.

(i) Unexpected event reports related to the Electrical Safety (get copies of the POM-172s);

(ii) Errors or other events that were recognized but did not warrant an unexpected event report;

(iii) PRO&M recommendations;

(iv) Corrective action plans from last year that were incomplete; and

(v) Other Electrical Safety related deficiencies.

(b) List corrective action plans and the status of those plans.

(8) Send a copy of the completed "Facility Electrical Safety Program Review" work order to the regional power manager and the Power Resources Office (85-51000).

(9) File copy of completed work order and all supporting materials.