RECLAMATION

Managing Water in the West

Facilities Instructions, Standards, and Techniques
Volume 5-14

Electrical Safety Program

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

August 2018
(FIST 012) 08/09/2018
SUPERSEDES FIST TRMR-5-14 (FIST 005) 12/18/2015 and minor revisions approved 12/15/2016, 06/08/2017, and 12/18/2017

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
7-12-2018	Final	Implementation Date: October 1, 2018

4. TITLE AND SUBTITLE
FIST 5-14, Electrical Safety Program

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S) 2018 Revision Team
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Power Resources Office, Bureau of Reclamation
Denver Federal Center
P.O. Box 25007
Denver CO 80225-0007

8. PERFORMING ORGANIZATION REPORT NUMBER
FIST 5-14

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Power Resources Office
Bureau of Reclamation
Mail Code 85-51000
PO Box 25007
Denver CO 80225-0007

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Available on Reclamation's intranet and internet websites.

13. SUPPLEMENTARY NOTES

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.

15. SUBJECT TERMS
Arc flash, personal protective clothing, energy level, arc blast, Incident Energy Analysis, personal protective equipment, labeling, approach boundary, arc flash protection, arc flash boundary, working distance, safety control strategies, risk assessment, evaluation, procedures, arc-rated clothing, incident energy, Arc Flash Hazard Analysis Report,.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Power Resources Office
U	U	U	U	53	19b. TELEPHONE NUMBER *(include area code)* (303) 445-2922

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. 239-18

(FIST 012) 08/09/2018
SUPERSEDES FIST TRMR-5-14 (FIST 005) 12/18/2015 and minor revisions approved 12/15/2016, 06/08/2017, and 12/18/2017

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(FIST 012) 08/09/2018
SUPERSEDES FIST TRMR-5-14 (FIST 005) 12/18/2015 and
minor revisions approved 12/15/2016, 06/08/2017, and 12/18/2017

Acronyms and Abbreviations

AC	Alternating current
ANSI	American National Standards Institute
AR	Arc rated
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
CARMA	Capital Asset and Resource Management Application
DC	Direct current
ESP	Electrical Safety Program
FESP	Facility Electrical Safety Program
FIST	Facilities Instructions, Standards, and Techniques
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
QEAL	Qualified Electrical Employee Authorization List
RSHS	Reclamation Safety and Health Standards
RO	Responsible official
SOPs	Standing Operating Procedures
TSC	Technical Service Center

Table of Contents

1.0 Introduction

{Each Reclamation facility must develop a facility electrical safety program (FESP).} The FESP consists 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. This document defines the safety control strategies to be used when employees have potential exposure to electrical shock hazards greater than **50 volts** or incident energies greater than **1.2 cal/cm^2**.

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 goal and includes basic electrical safety in the workplace, electrical safe working practices, policies, documentation, and standing operating procedures (SOPs). Reclamation's goal is to reduce employee exposure to electrical shock hazards and arc flash hazards with incident energies greater than **8 cal/cm^2**. By reducing the exposure to arc flash hazards with incident energy greater than **8 cal/cm^2**, Reclamation seeks to reduce the number of maintenance tasks that exposes an employee to the arc flash hazards requiring category 3 personal protective equipment (PPE) (PPE categories per NFPA 70E are listed below). Category 3 PPE may protect the worker from skin burn caused by a potential incident with higher level energy involved but, there are significant risks while wearing PPE of category 3 and above if an incident were to occur.

PPE Categories (NFPA 70E)

- PPE Category 1 – 4 cal/cm^2 minimum;
- PPE Category 2 – 8 cal/cm^2 minimum;
- PPE Category 3 – 25 cal/cm^2 minimum;
- PPE Category 4 – 40 cal/cm^2 minimum;

Use of category 3 and above PPE may be associated with the following additional risks in case of a higher level incident energy arc flash incident.

(1) Heat stress - Double layer fabric in the flash suit hood and the FR clothing creates a significant amount of heat stress due to the heat built up inside the protective gear.

(2) Pressure wave - Most flash suits and flash suit hoods are designed for the main purpose of skin burn protection and therefore offer limited protection from the blast pressure wave hazards. Incident energy at 8 cal/cm^2 and below poses significantly less risk from a blast.

(3) Reduced visibility and dexterity - The materials used in the flash suit visor may cause the distortion of colors, thus degrading the visibility. Multiple layers of fabric in the flash suit and hoods reduces the worker's dexterity, range of motion, and the ease of movement. All of these could potentially increase hazards while a work task is being performed.

It is ideal to minimize exposure to incident energy greater than 1.2 cal/cm^2, but it may not always be technically and economically feasible to reduce the incident energy to that level. For example, use of a fast bus trip protection scheme or instantaneous over current scheme may significantly reduce the incident energy, but they can create protection coordination issues with the downstream equipment which may include critical devices.

{Reclamation's objectives have 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.}

Implement safety control strategies to reduce the exposure to the employee when the incident energy is greater than 40 cal/cm^2.

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

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 interacting 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 includes a summary of the changes and a basis for the revision or new FIST. These forms are 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 red and black bold bracketed text.

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

2.0 Responsibility and Authority

2.1 Senior Advisor, Hydropower

The Senior Advisor, Hydropower, sponsors the ESP for Reclamation.

2.2 Manager, Asset Management Division

Asset Management Division sponsors the ESP for the Asset Management Division including the Facility O&M program.

2.3 Director, Technical Service Center

The Director, Technical Service Center (TSC), is responsible for:

(1) The implementation and oversight of the ESP for their employees and equipment.

(2) Ensuring TSC employees follow site specific Facility ESP procedures during their field activities.

2.4 Regional Director

The regional director is responsible for:

(1) Implementing the ESP.

(2) Ensuring the appropriate mitigation techniques are funded for specific instances where employee exposure limits exceed the Reclamation goal.

2.5 Area Managers and designated Responsible Official (RO).

[The Area Manager or designated RO must ensure that:

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

(2) An RO is designated and identified.

(3) Funding requests are developed and submitted where mitigation strategies are needed for all hazards that exposes employees to incident energy greater than 8 cal/cm^2.

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

(5) Employees are trained on the FESP.

(6) A Qualified Electrical Employee Authorization List (QEAL) is maintained.

(7) All FESP incidents are reported, investigated, documented, tracked and corrected.

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

(9) Reclamation non-facility personnel are trained or familiarized on the equipment based upon any special electrical safety requirements that apply to the scope of work they will be performing.]

2.6 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/or a Job Hazard Analysis (JHA) are developed and implemented that address shock and arc flash hazards and related safety control strategies including approval of risk assessments.

(4) The Area Manager or designated RO is notified of completed hazard assessments that exposes employees to incident energy greater than 8 cal/cm^2.

(5) Documentation including JHAs, Hazardous Energy Work Permits (HEWPs), Hazardous Energy Control Procedures (HECPs), and special work permits are complete, accurate, followed, filed, and retained for seven years.]

2.7 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.]

2.8 Contracting Officer's Representative (COR)

[The COR 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.]

2.9 Manager, PRO

[The Manager, PRO, is responsible for:

(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 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 changing requirements.

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

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

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

3.0 Facility Electrical Safety Program (FESP) and Procedures

{FIST 5-14 must be used to develop an 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 is designed to 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 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 documented risk assessments (which may be part of the JHA) for energized electrical work that does not meet the requirements for "normal operations" or exceptions.

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

(2) {A current QEAL must:

(a) Be maintained at each facility.

(b) Identify each qualified employee. The RO must determine the appropriate level of training for each employee based on their exposure.

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

3.1 FESP Program Review

[The FESP must be reviewed annually to verify that the established procedures are in place and properly being applied.]

[The review must be properly documented and maintained,] (for example, a CARMA work order with the name(s) of the person(s) who performed the review, the date of the review, and copies of any supporting documents, recommendations and corrective actions.) As required in FAC 04-02**, [all 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 will be sent to the area manager, regional power manager, and Manager, PRO.]**

[The Area Manager or designated RO must ensure that the FESP review adequately addresses the following areas:

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

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

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

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

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

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

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

(8) **Energized electrical safe work procedures are reviewed prior to each use.]**

An example of a FESP review job plan is available in Appendix D.

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 determined by the RO, as well as any specific electrical related safety practices outlined in this section that are necessary for their safety.}

The RO trains and assesses the abilities of their employees to perform work based on training and demonstrated proficiencies. The skills and knowledge required are developed and assessed through training and apprenticeship programs. Example proficiency sheets can be found in Appendix C.

4.2 Requirements

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

The PRO provides ESP standardized classroom presentations and exams (available from PRO upon request) and 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.

(1) **[Basic Electrical Safety Training**

Required for Reclamation employees annually as determined by RO. Should be presented to new employees during orientation.

(2) **Qualified Worker Electrical Safety Training**

Required for qualified employees every 3 years.
Should be presented to new employees during orientation.

(3) **Risk Assessment and Mitigation Training**

Required for all facility supervisors and any qualified employee responsible for risk assessment and mitigation, one time only.
Should be presented to new supervisory employees during orientation.]

(4) FIST 5-14 Implementation Training

Available for all Facility Supervisors.

4.3 Unqualified Employees

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

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 qualified employee must be trained in the use of appropriate tools and PPE.] 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 may 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 Worker Electrical Safety Training every 3 years.

(3) Training upon employment prior to performing any type of electrical work. 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.]**

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 risk assessment uses 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 includes a procedure 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

{The risk assessment (which may be part of the JHA) must identify the electrical hazards associated with the energized electrical work/task to be performed. A risk assessment must be performed before interacting with any system that has incident energy of 8 cal/cm^2 or greater.}

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

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

5.2 Assessing Risk

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

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 (2018) 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. The control strategies in section 5.3.1 through 5.3.6 are listed in descending order of effectiveness. While it is not a listed safety control strategy, consider body positioning for energized electrical equipment switching and/or interaction.

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 of this document, 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

Replacing equipment or changing procedures and processes may effectively eliminate or reduce the hazards to a 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

(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.

(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

(1) Emergency procedures.

(2) Employee training.

(3) Risk assessment.

(4) Job briefing.

(5) Increasing working distances (including remote racking and operating).

(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

(1) Considered the least effective of the safety controls.

(2) Last line of defense before an event happens.

(3) Properly arc rated (AR) 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.

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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. An electrically safe work condition is a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with FIST 1-1, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection. This section should be used when possible.

Establishing an electrically safe work condition includes:

{Verify the absence of voltage using an adequately rated test instrument to test each phase conductor or circuit part. Perform the de-energization verification test using a 3-point test method.} 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). Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Non-contact voltage detectors may be used as an alternative to direct contact meters but also follow the 3-point test method.

6.1 Personal Protective Grounding Installation

The primary purpose of personal protective grounding 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 until protective relays can operate to isolate the source of energy if the lines or equipment are accidentally energized.

The facility may choose to address the risk assessment for placement of personal protective grounds (PPGs) in either the overall risk assessment, the written grounding procedure, JHA or a specific risk assessment for the placement of grounds. Consider the following for a PPG risk assessment:

- Grounds are placed on circuits or conductors that have been disconnected from energized parts and locked/tagged as described in FIST 1-1;
- The shock hazard remains until PPG are applied to the circuit;
- The hierarchy of safety control strategies in descending order of effectiveness (Section 5.3) are employed to reduce hazard exposures;

- Placing grounds on the wrong equipment and other human errors create deadly consequences;
- Exposed equipment that is not locked/tagged per FIST 1-1 may be present in the work area and could be contacted by grounds, tools or body parts creating deadly consequences.
- Wearing full body coverage (including face and neck) 8 cal/cm^2 arc flash clothing or greater for complete body coverage is a basic safety control strategy to be implemented whenever PPGs are applied;
- PPGs are sized to carry fault current for a limited number of cycles and rely on the relay protection system being functional to initiate the opening of circuit interrupting devices upon inadvertent energization; and
- Continue to implement safety control strategies to reduce the exposure to the employee when the incident energy is greater than 40 cal/cm^2 .

{Only qualified personnel trained on proper PPG selection and installation are allowed to install PPGs.} FIST 5-1, Personal Protective Grounding for Electric Power Facilities and Power Lines; FIST 1-1, Hazardous Energy Control Program; and the Reclamation Safety and Health Standards (RSHS) Ch. 12 define the requirements to be followed where the possibility of reenergization, 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 RSHS Ch. 12 for the placement and removal of PPGs and specific details in FIST 5-1. These procedures will document the steps/tasks and the potential hazards for each step/task. The following minimum steps must be included in the procedures:

(1) **Ensure the equipment has been disconnected from energized parts and locked/tagged using the appropriate hazardous energy control procedure per FIST 1-1. Use the two-person rule to ensure the proper procedures are followed and to double-check locations, etc.**

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

(3) **Wear the appropriate PPE for each step/task as identified in the safety control strategies. A minimum level of 8 cal/cm^2 arc flash clothing and PPE is required when checking for absence of voltage and applying PPGs. Use appropriate shock hazard protection until the PPGs are fully applied. The shock protection boundaries remain in effect until PPGs are applied.}** Refer to the Incident Energy Analysis or arc flash labeling to determine the selection of the appropriate shock hazard PPE.

(4) **Verified for the absence of voltage by a 3-point test using the appropriate insulating tool/PPE.**

(5) **Touch or tap the exposed circuit parts using the PPGs to be applied with the appropriate insulating tool/PPE to verify the circuit is in a zero energy state and ensure there is no presence of voltage/current detected. Do not use a static ground or lower ampacity ground for this test.**

(6) **Apply PPGs using the appropriate insulating tool/PPE.}**

7.0 Interaction with Energized Electrical Equipment

Interaction is 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.

Safe work procedures (e.g., Facility SOPs, JHAs, HECPs, locally generated procedures, job plans, etc) are developed prior to work on any 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 procedures uses the hierarchy of safety control strategies identified in Section 5.3 to reduce potential hazards that employees are exposed to. These procedures become part of the overall FESP, and 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.

{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

{Normal operation of equipment involves interacting with the equipment, but for most equipment this does not meet the definition of working on. Normal operations of electrical equipment that has incident energy greater than 1.2 cal/cm^2 or less than 40 cal/cm^2 will be permitted where a normal operating condition exists. A normal operating condition exists when all of the following conditions are satisfied:

(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 is used in accordance with the manufacturer's instructions.

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

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

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

(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.}

Normal Operation assessment is not necessary for equipment that has incident energy less than 1.2 cal/cm^2. **{For equipment at or above 8 cal/cm^2 a written risk assessment will be performed before performing Normal Operation. An example of normal operation assessment can be found in Appendix E}.**

7.2 Interacting with or Working on Energized Electrical Equipment

{At least two employees must be present when performing any work involving 600v and above.}

{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 applies. 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 and the conductors or circuit parts are not exposed, but an increased likelihood of injury from an exposure to 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 (section 10.3) 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 protection boundaries.}

8.2 Approach Boundaries

{Boundaries must be established when an arc flash hazard or a shock hazard are present.} The arc flash hazard analysis must be referred to when determining the distances for shock protection and arc flash protection boundaries. In the absence of an arc flash study, the tables in NFPA 70E are used until an arc flash study is completed. If arc flash study is not available refer to NFPA 70E (2018) 130.4(D) (a) and (b) for shock protection boundaries and 130.7(C)(15)(a) and (b)

for arc flash protection boundaries and PPE selection requirements. The minimum arc flash boundary will be considered to be 3 feet if the arc flash study has not been performed for any electrical system 240V or below. Any arc flash boundary from the table that is less than 3 feet should be rounded up to this 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 protection boundary. The use of barricades and barriers 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 protection boundaries are only applicable when the hazard exists.

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

Figure 1. Marking arc flash hazard boundaries (with sign).

Figure 2. Marking arc flash hazard boundaries (with barricade).

9.0 PPE and Clothing

PPE includes 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.

9.1 Work Clothing within an Arc Flash Protection Boundary

{All employees within the arc flash protection boundary, regardless of work being performed, must wear non-melting, untreated, natural fiber 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 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.}

{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 130.7 (C) and Annex H.3 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, see FAC 04-02 Paragraph 5.G. for conflict resolution.

10.1 Incident Energy Analysis

Performing an Incident Energy Analysis is an integral part of an Arc Flash Hazard Analysis Report (See Section 10.4). 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 (2018) table 130.7(C) (15) (a) and 130.7(C) (15) (b)) 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 and updated 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 studies and Incident Energy Analysis. A qualified engineer is 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. To be designated as qualified and to maintain proficiency in this rapidly changing field of expertise the engineer performs these duties full time, not infrequently as a collateral duty. A qualified engineer has a professional engineer license and has 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 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.]**

[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 arc flash protection boundary can be determined by the applicable NFPA 70E tables.**

(4) **Determine tentative arc 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 are 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. 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.

10.4 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.]**

[The specification must 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.]

[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 source of possible injury or damage to health associated with the release of energy caused by an electric arc..

Informational Note No. 1: The likelihood of occurrence of an arc flash incident increases when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. An arc flash incident is not likely to occur under normal operating conditions when enclosed energized equipment has been properly installed and maintained.

Informational Note No. 2: See NFPA 70E Table 130.5(C) for examples of tasks that increase the likelihood of an arc flash incident occurring.

Arc Flash Hazard Analysis Report. A report performed for a specific facility, which likely contains 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 that describes their performance to exposure 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 from an arc source at which incident energy equals 1.2 cal/cm2 (5 J/cm2) 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 should 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: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm2 (5 J/cm2) for one second.

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.

Boundary, Shock Protection. Refers to either the limited approach or restricted approach boundary.

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 nonautomatic means 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.

De-energized. 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 arc blast injury.

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. Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.

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 verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection.

Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from unintentionally 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.

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 de-energize 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. The conductive path(s) 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 an arc flash risk assessment 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 the hazards and reduce the associated risk.

Reclamation Non-Facility Personnel: Any Reclamation personnel who are not employees at the facility as their primary duty station. 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. An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if 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 source of possible injury or damage to health associated with current through the body caused by contact or approach to energized electrical conductors or circuit parts..

Informational Note: Injury and damage to health resulting from shock is dependent on the magnitude of the electrical current, the power source frequency (e.g., 60 Hz, 50 Hz, dc), and the path and time duration of current through the body. The physiological reaction ranges from perception, muscular contractions, inability to let go, ventricular fibrillation, tissue burns, and death

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 distance between a person's face and chest area and a prospective arc source. Informational Note: Incident energy increases as the distance from the arc source decreases. See 130.5(C)(1) for further information.

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.).

Zero energy state. The point at which machinery or equipment has no energy flowing to or from it and as a result, does not have the potential to cause accidental physical harm or injury if handled in this state.

Appendix C – Training Proficiency Sheets

Please continue to the next page.

Basic Electrical Safety Awareness Training
Proficiency Sheet

Explain or Demonstrate Proficiency	YES	NO
1. Completion of Basic Electrical Safety Training.	☐	☐
2. Explain the consequences of violating Electrical Safety requirements.	☐	☐
3. Explain the relationship between exposure to potential electrical hazards and possible bodily injury.	☐	☐
4. Demonstrate how to identify electrical equipment.	☐	☐
5. Demonstrate how to identify exposed electrical equipment and components.	☐	☐
6. Explain what actions need to be taken before drilling into electrical panels, equipment or concrete.	☐	☐
7. Explain precautions to be taken when operating vehicles or working in the vicinity of overhead lines.	☐	☐
8. Explain the use of portable electric tools and what inspections should be performed.	☐	☐
9. Explain how to protect electrical cords from damage.	☐	☐
10. Explain why the ground terminal on a plug is important.	☐	☐
11. Explain why and where Ground Fault Circuit Interrupters should be used.	☐	☐
12. Explain the precautions that should be taken when using portable ladders.	☐	☐
13. Explain the precautions that should be taken when working in wet locations.	☐	☐
14. Explain the actions to be taken if damaged electrical equipment or devices are found.		
15. Explain how to identify equipment that may have impending failure.		
16. 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 less than or Equal to 600 Volt Nominal Proficiency Sheet

Explain or Demonstrate Proficiency	YES	NO
1. Completion of Basic Electrical Safety training.	☐	☐
2. Completion of Qualified Worker Electrical Safety Training	☐	☐
3. Define an electrically safe work condition.	☐	☐
4. Demonstrate the ability to follow safe work procedures and policies.	☐	☐
5. Demonstrate the ability to determine hazardous energy isolation boundaries.	☐	☐
6. Demonstrate the ability to read and understand arc flash labels.	☐	☐
7. Demonstrate the ability to determine proper safety requirements for arc flash in the absence of labels or an Incident Energy Analysis.	☐	☐
8. Utilize safe work practices for the equipment to be operated.	☐	☐
9. Determine appropriate PPE for the associated hazards.	☐	☐
10. Demonstrate proper use of PPE.	☐	☐
11. Demonstrate proper inspection, care, and maintenance of PPE.	☐	☐
12. Demonstrate proper switching techniques and body positioning.	☐	☐
13. 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.	☐	☐
14. Completion of first aid training and CPR certification.	☐	☐
15. Qualified as Authorized employee under FIST 1-1, Hazardous Energy Control Program.	☐	☐
16. 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 greater than 600 Volt Nominal Proficiency Sheet

Explain or Demonstrate Proficiency		YES	NO
(1)	**Completion of Basic Electrical Safety training.**	☐	☐
(2)	**Completion of Qualified Worker Electrical Safety Training.**	☐	☐
(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 de-energization 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 Worker Electrical Safety Training.**	☐	☐
(3)	**Completion of Qualified High Voltage Switchman Proficiency Sheet.**	☐	☐
(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 protection 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, multi-meters, 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 – 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 Electrical 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.

(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 the risk assessments updated and reviewed prior to each use?

(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 area manager; regional power manager; and Manager Power Resources Office (85-51000).

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

Appendix E – Normal Operations Assessment and Safety Control Strategy

FIST 5-14 Worksheet

Normal Operations Assessment and Safety Control Strategy

Facility:					Risk Assessment Number:					
Device/Equipment/Bus Identifier		Voltage (kV)	Protective Device		Arc Flash Boundary (in)		Working Distance (in)		Incident Energy (Cal/cm2)	
Normal Operations Evaluation	**All of the following conditions must be met to perform Normal Operation**									
	Is Equipment Properly Installed?			Yes		No				
	Has Equipment been Properly Maintained?			Yes		No				
	Are Doors Closed and Secured?			Yes		No				
	Are Covers Installed and secured?			Yes		No				
	No evidence of damage, overheating, or impending failure has been verified?			Yes		No				
	Increased risk of arc flash hazard has been considered?			Yes		No				
	Are protection devices properly maintained?			Yes		No				
	Configuration of protective systems has been verified?			Yes		No				
	If the answer to all the above is "Yes" then this device/equipment meets the "Normal Operations" requirement and can be operated without Arc Flash PPE.									
Safety Control Strategy	All devices/equipment that do not meet the "Normal Operations" requirements and have an incident energy greater than 8 Cal/cm2 must have a written Safety Control Procedure.									
	1	Elimination								
	2	Substitution								
	3	Engineering Controls								
	4	Awareness								
	5	Administrative Controls								
	6	PPE								
Safety Control Procedure:										
Safety Control Procedure Effectiveness:			Cal/cm2:			Minimum Distance from Device:		Employee exposure to incident energy >40 Cal/cm2 is prohibited		
Developed by:		Reviewed by:				Approved by:				
Approval Authority Required if Personnel Exposure cannot be reduced to 8 Cal/cm2:						Approved by:				

RECLAMATION
Managing Water in the West

RECLAMATION MANUAL TRANSMITTAL SHEET

Effective Date: **08/09/2018**

Release No. **FIST 012**

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

Reclamation Manual Release Number and Subject

FIST 5-14 Electrical Safety Program

Summary of Changes

SUPERSEDES FIST TRMR-5-14 (FIST 005) 12/18/2015 and minor revisions approved 12/15/2016, 06/08/2017, 12/18/2017

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

Filing instructions

Remove Sheets

Insert Sheets

See FIST 5-14 at https://www.usbr.gov/power/data/fist_pub.html

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

Filed by: _____

Date: _____