THE NATION'S URANIUM PROCESSING FACILITY

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REVISION LOG

Revision	Description	Intent	Non Intent
2	Incorporated into this manual the content of and supersedes UPF-CP-226, Rev 0 and UPF-CP-234, Rev 4. CFN-1261 was generated in this revision.	X	
1	Incorporated reference to UPF-CP-226 per CR: 25774-000-GCA-GAM-00336. Also added AHJ sign-off on Appendix F	X	
Previous revisions	On record	N/A	

CONTENTS

1.0 INTRODUCTION

1.1 Purpose

This manual provides responsibilities and requirements at the Uranium Processing Facility (UPF) for work performed on or near electrical energy sources—both temporary and permanent. The provisions of this manual apply to all work where there is a potential for workers to be exposed to a voltage of 50 volts (V) or more. The purpose is to ensure that all potential safety and health (S&H) hazards are identified and controlled, and are communicated to workers before they start working on or near electrical energy sources.

This manual ensures that all project work on or near electrical energy sources is performed in accordance with applicable electrical safety requirements, including the following National Fire Protection Association (NFPA) standard and Occupational Safety and Health Administration (OSHA) regulations in the Code of Federal Regulations (CFR):

- NFPA 70E, Standard for Electrical Safety in the Workplace 2015
- 29 CFR 1926, *Safety and Health Regulations for Construction*
- 29 CFR 1910, *Occupational Safety and Health Standards*"
  - 1910.137, *Electrical Protective Equipment*
  - 1910.147, *The Control of Hazardous Energy (Lockout/Tagout)*
  - 1910.269, *Electric Power Generation, Transmission, and Distribution*, Appendix C, *Working on Exposed Energized Parts*
  - 1910.303, *General*
  - 1910.304, *Wiring Design and Protection*
  - 1910.305, *Wiring Methods, Components, and Equipment for General Use*
  - 1910.332, *Training*
  - 1910.333, *Selection and Use of Work Practices*

1.2 Scope

This manual applies to all personnel (including subcontractor personnel) during the construction of the UPF.

2.0 RESPONSIBILITIES

2.1 Construction Manager

The Construction Manager (CM) has the overall responsibility for ensuring the implementation of this manual. In coordination with the Environment, Safety, and Health Manager, the CM carries out the following responsibilities:

- Ensuring that all UPF construction site personnel actively participate in assured equipment grounding safe work practices.
- Providing worker support, facilities, and other resources necessary to effectively carry out manual required safe work practices.

2.2 Environment, Safety, and Health Manager

The Environment, Safety, and Health (ES&H) Manager assists in interpreting regulations associated with the manual and the interpretation of the manual as to intent and application.

ES&H Manager will consult with Authority Having Jurisdiction for manual implementation guidance.

2.3 Lead Electrical Superintendent

The Lead Electrical Superintendent is responsible for verifying that all employees within their organizations working with electrical equipment are knowledgeable of the contents of this manual, and are properly trained and qualified for each voltage or hazard level of work or task being assigned.

2.4 Supervisors

Supervisors are responsible for:

- Verifying that all employees working around electrical equipment have been trained, qualified and properly instructed regarding the hazards of specific equipment.
- Being familiar with and implementing the requirements in this manual.
- Reviewing each job involving electrical equipment and identifying hazardous voltages to ensure that safe manuals are being followed.
- Preparing or providing the required job hazard analyses (JHAs) for assigned jobs, and reviewing them with assigned employees.
- Submitting JHAs to the ES&H Representative for review and completion.
- Planning work activities in advance to identify the appropriate tools and equipment to use.
- Ensuring workers understand the requirements of the manual.
- Verifying that all assigned employees are trained and qualified for the level of work involved and that the employees do not perform work alone on energized circuits or equipment at 50 V or more.
- Ensuring that safety equipment necessary to perform work tasks required by this manual is identified and provided in proper working order.
- Verifying that the Personal Protective Equipment (PPE) selected for a work task meets the intent of this manual.
- Completing a safety task analysis and risk reduction talk (STARRT) card for energized work.
- Determining the limited approach boundary (LAB) and the flash protection boundary (FPB).
- Preparing the energized electrical work permits (EEWPs).
- Ensuring that protective shields are installed where appropriate to prevent workers from inadvertently coming in contact with energized equipment.
- Maintaining the EEWP log.

2.5 Qualified Electrical Personnel

All qualified electrical personnel are responsible for:

- Complying with this manual.
- Being trained and qualified for the level of work involved.

NOTE: *Do not work alone on energized circuits or equipment at 50V or more.*

- Participating in the development and/or preparation of the JHA for the assigned job, as directed by the supervisor.
- Reporting any unsafe practices, both to the individual involved and to their supervisor.
- Demonstrating competence in the skills, knowledge, and techniques necessary to distinguish exposed energized parts from other parts of the equipment, and demonstrating they have received training to recognize and avoid the hazards involved (see NFPA 70E).
- Demonstrating competence in the proper use of special precautionary techniques, PPE, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment.

2.6 UPF Construction Site Electricians

All UPF construction site electricians are responsible for understanding and complying with the requirements of this manual. They are responsible for not only knowing how to apply assured equipment grounding safe work practices to work safely, but also pausing or stopping work when they observe unsafe conditions developing or new hazards emerging in their work area.

2.7 Environment, Safety and Health Representative

NOTE: *The Environment, Safety, and Health (ES&H) Manager has the authority for assisting in the interpretation of the regulations associated with the manual and the interpretation of the manual as to intent and application.*

The ES&H Representative is responsible for:

- Reviewing and, if applicable, approving JHAs and EEWPs.
- Assisting in the development of JHAs and EEWPs, when requested.
- Reviewing assigned electrical PPE, when requested.
- Providing field electrical safety oversight.

2.8 Project Engineer (or Designee)

The Project Engineer or designee is responsible for providing all calculations for arc flash and approach boundaries in accordance with IEEE Standard 1584, *Guide for Performing Arc-Flash Hazard Calculations*.

2.9 Training Manager

The Training Manager is responsible for:

- Tracking and maintaining all electrical safety training records.
- Maintaining the training database.

3.0 PROCESS

3.1 General Requirements

The requirements in this section shall apply to all employees who perform tasks that could expose them to electrical shock hazards that are not reduced to a safe level through the applicable electrical installation requirements.

Areas to which access is limited by LAB requirements will be released after protection shields are installed and no exposed energized components remain to pose a hazard.

The organization performing work within the LAB or FPB shall also follow these requirements:

A. The assigned employees and supervisor must complete a pre-job STARRT card and JHA to communicate known hazards to each employee in the designated work area. The STARRT card and JHA are required on all work activities. All assigned employees must sign the STARRT card and JHA, acknowledging their review before starting work.

B. Red and black “DANGER” barrier tape is required to be installed as a visible barrier to preclude unauthorized entry into the LAB or FPB from all accessible directions. Additionally, a sign or tag identifying the hazard shall be present at the barrier.

C. The assigned employees shall ensure all others in the vicinity are kept outside the LAB and FPB when work is being performed. The assigned employees may allow qualified employees and escorted employees to cross the LAB and FPB when it is safe to do so. Two qualified electrical persons are required when testing is being performed, and all personnel inside the LAB or FPB are required to wear the same level of PPE.

D. The employee performing the actual hands-on work must be a qualified electrical person. Other employees assigned to the scope of work cannot perform the work in the LAB and/or the FPB.

E. An ABC-rated fire extinguisher must be readily available at the work site. This manual defines the work site as the barricaded area immediately adjacent to the location where the physical work is being performed.

F. The work area must be dry, adequately illuminated, and free of obstructions and debris that may become a hazard or interfere with the work activity.

G. Tools must be kept in temporary storage while not in use. Tools shall not be placed on top of cabinets or any other item where they could possibly fall onto energized components.

H. Before a conductor may be pulled through an area with exposed energized components, the ends of the conductor shall be sufficiently protected with an insulating material of the same rating as the conductor itself. If a pulling device is used, it must be made of a nonconductive material.

I. Only voltage-rated tools (including non-conducting ladders) shall be used in the vicinity of live electrical conductors.

3.2 Work On or Near Energized Circuits

A. Live parts to which an employee may be exposed shall be de-energized before the employee works on or near them, unless it can be demonstrated that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Before a battery system may be worked on, a risk assessment shall be performed to identify the chemical, electric shock, and arc flash hazards and to assess the risks associated with the types of tasks to be performed. Live parts of

equipment operating at less than 50 V need not be de-energized if there will be no increased exposure to electrical burns or to explosion due to electrical arcs.

1. Examples of additional or increased hazards that de-energizing may bring about include the following:
   - Interruption of life support equipment
   - Deactivation of emergency alarm systems
   - Shutdown of hazardous location ventilation equipment
   - Removal of illumination for an area
2. Examples of work that may be performed on or near energized circuit parts because equipment design or operational limitations make it infeasible to shut down the equipment include the following:
   - Testing or troubleshooting of a circuit that can be performed only when the circuit is energized
   - Work on a circuit or piece of equipment that cannot be isolated from an operating process or safety system that requires continuous, uninterrupted operation (i.e., the process or system cannot be shut down completely).
3. When work is planned to be performed on electrical circuits, components, or equipment, all sources of potential energy shall be identified during the work planning process. If it is not possible to identify all such sources because necessary drawings or other information is not available, the work shall be considered energized electrical work in accordance with this manual. Only after a physical walk-down occurs and isolation from all potential energy sources is verified shall Lock Out Tag Out (LOTO) be used, and the work will no longer be considered energized electrical work.
4. When circumstances require work on energized electrical systems, the following protective measures shall be implemented:
   - All electrical work will be performed by qualified electrical personnel.
   - All required permits (in particular EEWPs) shall be completed prior to commencement of work.
   - All tools and inspection equipment shall be insulated and rated for the voltage of the energized equipment.
   - Only PPE that is designed and rated for the voltage of the energized equipment shall be used.

B. Two qualified electrical persons shall be present and within the immediate area at all times while work is being performed on potentially energized electrical equipment at 50 V or more. Use of an intercom or radio is not an acceptable substitute for this requirement. This requirement does not apply to the use of electrical portable hand tools (e.g., drills, saws), or completely enclosed electronic equipment of conventional type (e.g., computers, copiers, fax machines). The second person (i.e., the Buddy Safety Observer (B/SO)) must be present and within the immediate area while the work is being performed.
   1. The B/SO must know which breaker to open if it becomes necessary to shut off the power in case of emergency.
   2. One employee can work alone if performing a visual inspection or monitoring functions only. The employee shall not break the plane of the FPB.

C. When working on energized devices, the assigned employee will, when possible, work with one hand, with the other hand not touching a grounded item.

D. All work inside the restricted approach boundary that has energized circuits with exposed non-insulated parts shall be considered energized work if the plane of the restricted approach boundary is broken during the course of that work activity with tools or body parts.

E. When electrical work is to be performed in confined or enclosed work spaces (e.g., manholes, vaults), the following rules must be followed:
   1. Protective shields, barriers, and/or insulating materials shall be used to prevent inadvertent contact with exposed energized parts over 50 V.
   2. Doors and hinged panels that are of sufficient weight or can be "moved" by the wind so as to push an employee into an exposed electrical circuit shall be secured to prevent their movement.
   3. A Confined Space Entry Permit evaluation must be performed prior to issuing a permit and entering the confined space.
   4. Safe working distances must be maintained as specified in Table 1.

Table 1. Working Distances

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
51–150 V	3 ft	3 ft	3 ft
151–600 V	3 ft	3½ ft	4 ft

Note: Use the greater distance (FPB or LAB) to trigger the need for PPE.

F. Safe Working Distances—600 V, Nominal, or Less
   1. Sufficient access and working space shall be provided and maintained around all electrical equipment to permit ready and safe operation and maintenance of such equipment.
   2. The depth of the working space in the direction of access to live parts shall not be less than indicated in Table 1. Distances shall be measured from the live parts if such are exposed or from the enclosure front or opening if such are enclosed.
   3. Conditions and exceptions for safe working distances are as follows:
      - *Condition 1.* Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not over 300 V shall not be considered live parts.
      - *Condition 2.* Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered grounded surfaces.
      - *Condition 3.* Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.
        a) *Exception 1.* Working space shall not be required in back or sides of assemblies, such as dead-front switchboards or motor control centers (MCCs), where (a) there are no replaceable or adjustable parts (e.g., fuses, switches) on the back or sides, and (b) where all connections are accessible from locations other than the back or sides. Where rear access is required for work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 inches (in.) shall be provided.

b) *Exception 2.* By special permission, smaller spaces shall be permitted where all uninsulated parts are at a voltage no greater than 50 V, or 60 volts direct current (VDC).

c) *Exception 3.* In existing buildings where electrical equipment is being replaced, the Condition 2 working clearance shall be permitted between dead-front switchboards, panel boards, or MCCs located across from each other under the following circumstances: (a) written manuals that prohibit equipment on both sides of the aisle from being open at the same time have been adopted; and (b) only qualified and authorized persons will service the installation.

4. The width of the working space in front of the electrical equipment shall be the width of the equipment or 30 in., whichever is greater. In all cases, the work space shall permit at least a 90-degree opening of equipment doors or hinged panels.
5. Working space required by this manual shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be suitably guarded.
6. The minimum headroom of working space above service equipment, switchboards, panel boards, or MCCs shall be 6½ feet. Where the electrical equipment exceeds 6½ fee in height, the minimum headroom shall not be less than the height of the equipment.

G. Safe Working Distances—600 V, Nominal, or More

1. Conditions for safe working distances are as follows:
   a) *Condition 1.* Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not over 300 V shall not be considered live parts.
   b) *Condition 2.* Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered grounded surfaces.
   c) *Condition 3.* Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.
2. Conductive articles of clothing shall not be worn (e.g., watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread metal, headgear or belt buckles) unless such articles are rendered nonconductive by covering, wrapping, or other insulating means.
3. Before issuing a permit to work on or near electrical devices operating at 600 V, nominal, or more, the supervisor must research all options to de-energize the devices.

Table 2. Minimum Depth of Clear Distance at Electrical Equipment

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
601–2500 V	3 ft	4 ft	5 ft
2501–9000 V	4 ft	5 ft	6 ft
9001—25,000 V	5 ft	6 ft	9 ft
25,001–75,000 V	6 ft	8 ft	10 ft

>75,000 V	8 ft	10 ft	12 ft

Note: Use a greater distance (FPB or LAB) to trigger the need for PPE.

H. Employees must, at a minimum, follow the electrical safety requirements in APPENDIX B when working on energized circuits for those applications involving up to 600 V, nominal.

I. Additional considerations include the following:

a) Insulating material (e.g., rubber matting) must be undamaged, clean, and dry, and must be appropriate for the voltage.

b) Workers must use insulated tools when working on energized circuits. Tools must be inspected for defects before use.

c) Workers must wear rubber gloves (electrical) when working on energized circuits. Rubber gloves must be properly rated, tested, and certified for maintenance operations in accordance with the OSHA requirements specified in 29 CFR 1910.137.

d) Workers must wear undergarments that are Fire Retardant or 100 percent cotton when working on energized electrical circuits, or when working on circuits that appear to be de-energized but have not been verified.

e) Workers must always wear shoes with nonconductive soles when working on energized circuits.

f) All exposed electrical sources must be covered to prevent workers from touching them.

J. The requirements of this manual do not apply to tasks such as those listed below:

1. Changing out light bulbs, as long as there are no exposed wires, the only work on the circuit is to change a bulb out in an undamaged permanent fixture, and the bulb is not a high-temperature quartz iodide bulb. The quartz iodide (high-wattage halogen) bulbs, when energized, are instantaneously 350 degrees Fahrenheit (°F) and require de-energizing the fixture before the bulb may be changed out. Severe burns may result if the bulb is put into an energized circuit with bare hands. Where practical, the light fixture should be turned off before changing the bulb. This will require a lockout if exclusive control cannot be ensured.
2. The changing of fuses that are designed to break contact with the energized circuit before physical contact can be made with any part of the fuse.

3.3 Overhead Transmission Power Lines

- When heavy equipment must be moved or operated near overhead power transmission lines on or adjacent to the UPF construction site or site road, comply with applicable requirements in section 3.3.1 of this manual.
- As a general rule, the following controls will be implemented:
  - A risk assessment must be conducted (e.g., job hazard analysis or similar method).
  - Work must be planned, as far as practical, to avoid close proximity to the overhead lines and accidental contact.
- In addition to the use of heavy equipment, the following activities must be controlled in areas where overhead power lines are present (e.g., cranes):
  - Erecting scaffolding and handling scaffold tubes
  - Handling long ladders
  - Operating mobile elevated work platforms

- Elevating dump truck or front end loader

3.3.1 Reviewing Transport Routes With Overhead Utilities

Prior to moving heavy equipment across the UPF construction site and support areas the DS/Supervisor, with support from Field Engineering, are to review the travel route. As part of the review, overhead obstructions or energized utilities are identified and evaluated to determine if a haul plan needs to be developed for the movement of the heavy equipment (reference Y17-95-64-871, *UPF Construction Hoisting and Rigging Work Operations).*

3.3.2 Transporting Heavy Equipment Over Routes With Overhead Utilities

This section establishes criteria that must be met for heavy equipment (e.g. cranes, elevated dump truck, front end loader, etc.) traveling under or near a power lines. The Disciplined Superintendent/Supervisor must ensure that:

- All parts of the equipment are lowered/stowed sufficiently to meet height restrictions.
- The clearances specified in **Table 3** of this section are maintained.
- Effects of speed and terrain on equipment movement (including movement of the boom/mast) are considered to ensure that the minimum clearance distances specified in **Table 3** of this section are not breached.
-
- When traveling at night or in conditions of poor visibility, in addition to the measures specified above, make plans to ensure that the power lines are illuminated or another means of identifying the location of the lines is used.

Table 3 – Power Line Clearance Minimums During Transport

Normal Voltage	**Limited Approach Boundary** (Minimum)	**Y17-95-6Y-871** (Transport Criteria)
< 600 V	4 ft.	7 ft.
13.8 kV	6 ft.	9 ft.
161 kV	10 ft.	13 ft.
*Normal Voltage are the standard installations found on the Y-12 facility and expected to be encountered by UPF work operations. **All work performed at UPF support areas (off-site) shall be evaluated to identify the power line voltage and required clearances.		

3.3.3 Heavy Equipment Assembly/Disassembly Near Overhead Utilities

Assembly/disassembly of heavy equipment below power lines is prohibited. No part of the equipment, load line, or load (including rigging and lifting accessories), whether partially or fully assembled, is allowed below a power line unless it has been confirmed that the utility owner/operator has de-energized and (at the worksite) visibly grounded the power line.

3.3.4 Heavy Equipment Operations Near Overhead Utilities

- The Bechtel Core Process 234 defines an area surrounding every power line that is referred to as the Absolute Limit of Approach (ALA). Except when equipment is in transit, it is strictly forbidden to park, place, or move any crane boom, load line, or heavy equipment into this area to conduct work.
- The area surrounding each power line will be established as an ALA Boundary. Work is prohibited beyond the boundary unless the line has been de-energized or insulated.

- The ALA varies according to the following:

Table 4 – Power Line Absolute Limit of Approach

Line Voltage (nominal, kV)	ALA Distance
Up to 25 kV	30 ft.
Over 25 kV	50 ft.

- When working in close proximity to power lines, contact the utility system owner to determine the line voltage and if the lines can be de-energized or insulated.

NOTE: *All overhead lines are considered energized unless and until the person owning the line or the electric utility authorities indicate that it is not an energized line and that it has been visibly grounded.*

3.3.5 Establishing Exclusion Zones/Warnings

- For overhead power lines on the UPF construction site or support areas erect and maintain an elevated warning line, barricade, line of signs, or equivalent along the ALA Boundary, in view of an equipment operator, equipped with flags or similar high-visibility markings.
- During a work operation, if the equipment operator is unable to see the warning line while performing the work, establish the following:
  - A dedicated spotter to provide warning of boundary encroachment, and
  - A boom range control warning device set to give the operator sufficient warning when approaching the boundary.
- Identify and post clearance heights for all overhead utilities located over established haul routes on the UPF construction site and support areas.

3.4 Underground Utilities and Anomalies

- Prior to traveling an identified route or working in an area, Engineering should perform an evaluation and characterization of the areas for underground utilities or subsurface anomalies (cavities, soft soil, etc.). Do not perform heavy equipment operations until it has been determined that ground conditions are firm, drained, and graded to a sufficient extent so that, in conjunction (if necessary) with the use of supporting materials (e.g., crane mats), the equipment manufacturer's specifications are met. Establish precautionary requirements based on:
  - The type of utility system.
  - Whether the system is allegedly in service or out of service.
  - Age of the system installation, etc.
- Perform excavating activities and underground utility clearance/avoidance in accordance with Y17-95-64-822, *UPF Site Excavation and Backfill.*

3.5 Electrical Equipment

For all 120 V or 240 V, single-phase receptacles and portable power tools, equipment must comply with either the assured grounding program or the Ground Fault Circuit Interrupter (GFCI) requirements as specified below.

- Employees will visually inspect receptacles, extension cords, and equipment connected to cord and plug before each day's use in order to determine whether there are external defects. Where there is evidence of damage, the damaged item will be taken out of service and tagged with a defective tool tag. Refer to UPF-CP-200, *UPF General Safe Work Practices*.
- A test for all circuitry will be performed on all cords and receptacles that are not part of the permanent wiring system. All electrical equipment plugged into those cords and receptacles will have a grounding/earthing line. These tests will be made, recorded, and retained by the Electrical Department. All equipment that undergoes this test will be marked with electrician's tape in accordance with ML-SH-801768-A001, *UPF Color Code List for Documentation of Inspections*.
- All equipment ground/earth conductor continuity tests and electrical continuity and polarity tests will be performed as follows:
  - Before first use of the equipment
  - At intervals not to exceed three (3) months
  - Before repaired equipment is returned to service
  - Before equipment is used after any incident that may have caused damage
- Any equipment not passing the continuity test will be repaired immediately or tagged with a defective tool tag.
- Repaired equipment must pass the continuity test before it may be returned to service.

3.6 Power Generators

- Generators and welding transformers will be maintained in a serviceable condition.
- Fuel tanks will be located in areas with containment provisions rated to 110% of the total tank contents.
- The area around generators will be maintained free of oil and diesel spills.
- Rotating components will be guarded.
- Grounding/earthing will be provided on all mobile electrical generators.
- Outlets will be in good condition (e.g. no cracked outlets, outlet cover without damage that exposes conductors, etc.).

3.7 Distribution

- Distribution boards shall have GFCIs or residual-current devices fitted.
- Terminal points will be in an enclosure via rubber/plastic grommets.
- Distribution panels will be kept locked and the keys held by authorized personnel only.
- Cables shall be of a size and rating suitable for purpose.
- Grounding/earthing will be fitted to all distribution boards and metal support frames.
- Splicing of cables will only be allowed if in accordance with a field sketch; cables will be extended or repaired with the correct fittings.
- Domestic standard cables and fittings will not be allowed on site. All cables shall be to a construction standard and resistant to damage/wear and tear.
- Particular attention will be given to cable management to ensure that cables are routed in a manner that does not create an obstruction or trip hazard. The method of such

routing shall be in a manner that does not damage or affect the integrity of the cable. Refer to UPF-CP-200, *UPF General Safe Work Practices*.

3.8 Flash Hazard Protection

A. Additional safety-related work practices shall be used to protect employees (including observers, transients, etc.) who might be exposed to the electrical hazards involved if the live parts are not placed into electrically safe work conditions. Such work practices shall protect each employee from the arc flash and from contact with live parts directly with any part of the body or indirectly through some other conductive object. The work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the live parts.

B. The flash hazard analysis is used to determine the FPB and the PPE required within the FPB. The flash hazard analysis to determine FPB and PPE requirements must be performed by a Project Engineer for applications greater than 600 V. The primary means of documenting the flash hazard analysis is the EEWP. Flash hazard analyses shall be done before the assigned employee approaches any exposed electrical conductor or circuit part that has not been placed into an electrically safe work condition.

1. If a flash hazard analysis calculation has been performed by a Project Engineer, the value of the incident energy exposure (in cal/cm^2) may be used to determine the appropriate hazard risk category from APPENDIX C, Section C1. Whether the flash protection category is determined with APPENDIX B, or with a flash hazard analysis/calculation and APPENDIX C, Section C1, the proper level of PPE for arc flash protection is determined by consulting APPENDIX C, Section C2, and selecting the column representing the hazard risk category number that has been determined.
2. In certain instances, the FPB might be a greater distance than the LAB and the greater distance shall be used to trigger the need for PPE.

C. NFPA 70E specifies the requirement of PPE for employees within the FPB. All parts of the body that may be exposed to the arc flash need to be covered by the appropriate type and quality of PPE. The entire PPE set may be comprised of FR helmet or headgear, face shield, safety glasses, gloves, shoes, etc. depending upon the magnitude of the arc energy.

- The FPB shall be calculated by a qualified Project Engineer in accordance with the general formula in APPENDIX D. The protective clothing shall limit the incident energy reaching the chest/face of the employee to less than 1.2 calories/centimeter squared. FR clothing provides thermal insulation and is also self-extinguishing. Protective clothing is rated in cal/cm^2.

3.9 Shock Hazard Protection

Figure 1 depicts a representation of approach boundaries in relation to shock hazard PPE.

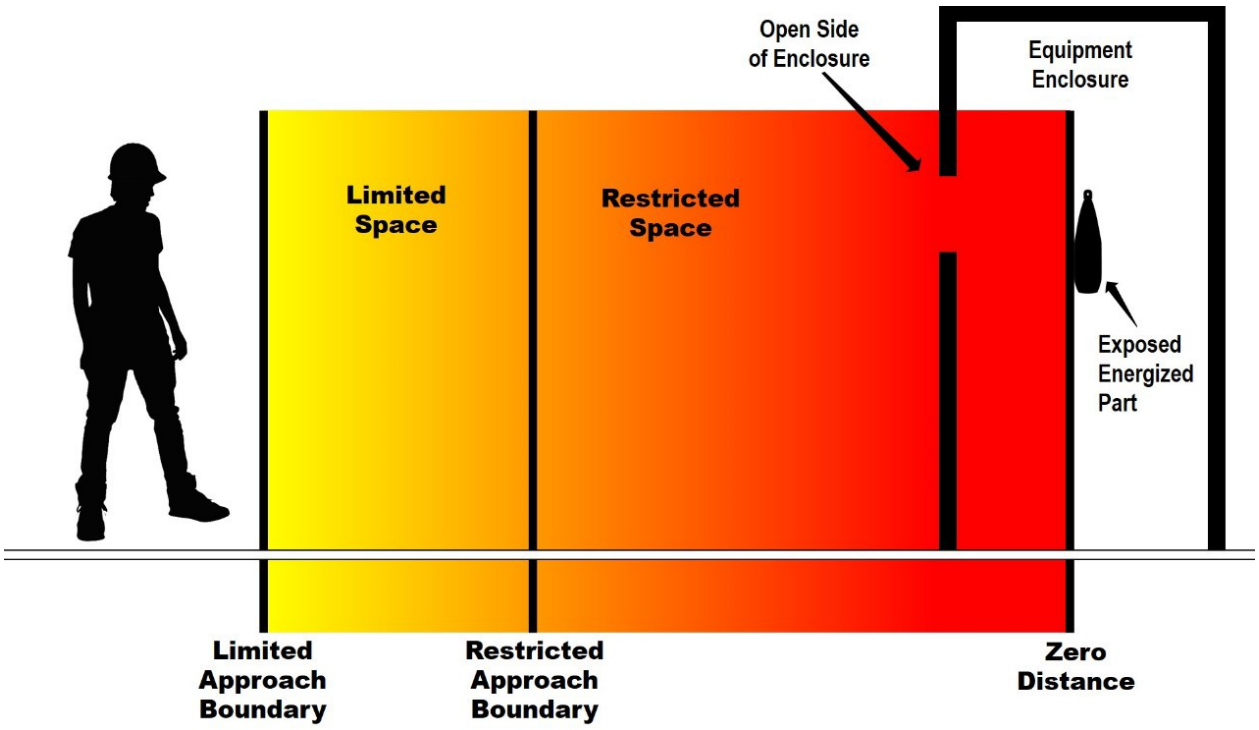

Figure 1. Approach boundaries.

D. Table 5 provides approach distances to exposed energized electrical conductors. The table identifies boundaries for limited approach and restricted approach.

Table 5. Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection

Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder
	Exposed Movable Conductor	Exposed Fixed Circuit Part	
<50 V	Not specified	Not specified	Not specified
50–150 V	10 ft 0 in.	3 ft 6 in.	Avoid Contact
151–750 V	10 ft 0 in.	3 ft 6 in.	1 ft 0 in.
751 V–15 kV	10 ft 0 in.	5 ft 0 in.	2 ft 2 in.
15.1–36 kV	10 ft 0 in.	6 ft 0 in.	2 ft 7 in.
36.1–46 kV	10 ft 0 in.	8 ft 0 in.	2 ft 9 in.
46.1–72.5 kV	10 ft 0 in.	8 ft 0 in.	3 ft 3 in.
72.6–121 kV	10 ft 8 in.	8 ft 0 in.	3 ft 4 in.
138–145 kV	11 ft 0 in.	10 ft 0 in.	3 ft 10 in.
161–169 kV	11 ft 8 in.	11 ft 8 in.	4 ft 3 in.

Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder
	Exposed Movable Conductor	Exposed Fixed Circuit Part	
230–242 kV	13 ft 0 in.	13 ft 0 in.	5 ft 8 in.
345–362 kV	15 ft 4 in.	15 ft 4 in.	9 ft 2 in.
500–550 kV	19 ft 0 in.	19 ft 0 in.	11 ft 10 in.
765–800 kV	23 ft 9 in.	23 ft 9 in.	15 ft 11 in.

Source: NFPA 70E (2015)
Note: All dimensions are distance from energized electrical conductor or circuit part to employee.

Table 6. Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection, Direct-Current Voltage System

Nominal Potential Difference	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder
	Exposed Movable Conductor*	Exposed Fixed Circuit Part	
<100 V	Not specified	Not specified	Not specified
100–300 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid Contact
301 V–1 kV	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	1 ft 0 in.
1.1–5 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	1 ft 5 in.
5 kV–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	2 ft 2 in.
15.1–45 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	2 ft 9 in.
45.1–75 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	3 ft 2 in.
75.5 kV–150 kV	3.3 m (10 ft 8 in.)	3.0 m (10 ft 0 in.)	4 ft 0 in.
150.1 kV–250 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	5 ft 3 in.
250.1 kV–500 kV	6.0 m (20 ft 0 in.)	6.0 m (20 ft 0 in.)	11 ft 6 in.
500.0 kV–800 kV	8.0 m (26 ft 0 in.)	8.0 m (26 ft 0 in.)	16 ft 5 in.

Source: NFPA 70E (2015)
Note: All dimensions are distance from energized electrical conductor or circuit parts to employee.
**Exposed movable conductor* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

1. The *Limited Approach Boundary* is the limit of approach distance for unqualified persons to a live part. In concept, unqualified people are less capable of recognizing a shock and flash hazard; therefore, these persons should remain at a safer distance from open, energized conductors. When there is a need for an unqualified person to cross the LAB to perform a minor task or look at equipment, a qualified person shall advise them of the possible hazards and ensure the unqualified person is safeguarded. Under no circumstances shall an unqualified person be permitted to cross the restricted approach boundary.
2. The *Restricted Approach Boundary* is the closest distance for a qualified person. Under no circumstances shall an unqualified person be permitted to cross the

restricted approach boundary. To cross this boundary, a person must meet all the following criteria:

- Be a qualified and authorized person.
- Have an approved EEWP except for testing and troubleshooting.
- Use arc flash rated PPE, approved for the conditions.
- Position the body in a way that minimizes risk of inadvertent contact in some instances. Work outside the restricted approach boundary (but within the person's reach) may be classified as restricted work if, in the judgment of the personnel involved, conductive objects or ungrounded body parts could make unintentional contact.

3. The *Restricted Space* is the area within the restricted approach boundary where personnel could be exposed to energized conductor or circuit part.

   To cross this boundary and enter the restricted space shall be considered the same as making contact with exposed energized conductors or circuit parts. To cross the restricted space, the qualified person must do the following:

   - Have specified training to work on energized conductors or circuit parts.
   - Have a documented plan that justifies the need to work inside the restricted approach boundary.
   - Perform a flash hazard risk analysis.
   - Have both the documented justification plan and the flash hazard risk analysis approved by the CM or designee.

E. Test equipment, tools, safety equipment, PPE, approvals, attendance, and backup person requirements shall be used in accordance with APPENDIX B.

Electrical equipment, such as switchboards, panel boards, industrial control panels, meter socket enclosures, and motor control centers, that are in other than dwelling units, and that are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field marked with a label containing all the following information:

1. Nominal system voltage
2. Arc flash boundary
3. At least one of the following:
   a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(A)(b) or Table 130.7(C)(15)(B) for the equipment, but not both.
   b. Minimum arc rating of clothing
   c. Site specific level of PPE

3.10 Energized Electrical Work Permit

A. Working on or near live parts and/or exposed energized electrical equipment requires the completion of an EEWP (see CFN-1194, UPF Exchanger Inspection Record), and shall only be permitted after the work group has determined that the energy isolation cannot be reasonably accomplished or the needed data can best be obtained while the circuit is energized.

B. If the exposed energized components cannot be electrically isolated, the Supervisor or their designee shall:

1. Complete, as applicable, a STARRT card or JHA for each scope based on specific configurations. The STARRT card and JHA are required on all work activities, except a STARRT card and JHA (in lieu of the JHA) are required when voltages exceed 600 volts alternation current (VAC) and 250 VDC.
2. Determine the LAB, FPB, and PPE requirements.
3. Mitigate hazards, when feasible, by installing protective shields and/or barriers where appropriate to prevent accidental contact by employees, materials, and tools with exposed energized equipment.
4. Verify appropriate PPE and tools are used by the employees.
5. Prepare the EEWP in accordance with APPENDIX E.

C. The following items, at a minimum, shall be documented on the EEWP for energized electrical work:
1. Description of the circuits and equipment to be worked on, and their location
2. Justification for why the work must be performed in an energized condition
3. Description of the safe work practices to be employed
4. Determination of the LAB for exposed energized parts for unqualified employees
5. Determination of restricted and prohibitive approach boundaries for qualified employees
6. Results of the flash hazard analysis
7. Approach boundary for flash protection (FPB)
8. Identification of necessary PPE to safely perform the assigned task
9. Barriers employed to restrict the access of unqualified persons from the work area
10. Evidence of completion of a job briefing, including a discussion of any job-specific hazards
11. Energized work approval signature(s)

D. Exemptions to Work Permit. An energized electrical work permit shall not be required if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with NFPA70E under any of the following conditions:
1. Testing, troubleshooting, and voltage measure
2. Thermography and visual inspections if the restricted approach boundary is not crossed
3. Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed

General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed.

3.11 Powered Hand Tool Cords and Extension Cords

A. Before initial use and prior to each use thereafter; attachment plugs, receptacles, cover plates, and cord connectors are visually inspected by the employee who is assigned to use the equipment. If any of the conditions listed below exist, the equipment is tagged with a defective tool tag and returned to the tool crib for repair or disposal:
- Breaks, damage, or cracks exposing live components or loss of insulation on electrical conductors or wiring
- Missing cover plates

- Terminations with stray strands or loose terminals
- Missing, loose, altered, or damaged blades, pins, or contacts
- Frayed or damaged cords

B. In addition to the inspection by the assigned employee, a qualified electrical person will conduct quarterly inspections on GFCIs.

Table 4. Inspection Schedule and Marking Colors

12. If the cord does not pass inspection, the equipment is tagged with a “DO NOT USE” tag and returned to the tool crib for repair or disposal.

C. All extension cords, regardless of whether used indoors or outdoors, shall be protected by GFCIs.

Table 7. Inspection Schedule and Marking Colors

Quarter	Months	Color
1	January, February, March	Yellow
2	April, May, June	Green
3	July, August, September	Red
4	October, November, December	Blue

D. Cords shall not be used to raise or lower equipment.

E. Cords shall not be fastened with staples or otherwise hung so that damage can occur to the outer jacket or insulation.

F. Extension cords shall be protected from accidental damage. Sharp corners and projections shall be avoided. Extension cords shall not pass through walls, doors, partitions, or other pinch points, or otherwise be subject to physical damage, unless protections are provided to avoid damage.

G. Extension cords shall not substitute for the fixed wiring of a structure, but may be used under the following conditions:

1. Extension cord connected to a UL-listed appliance or used in a UL-listed extension cord set is considered protected as long as the appliance or extension cord is used in accordance with its UL requirements.
2. The maximum load attached to the extension cord must not exceed the cord’s listed capacity.
3. Where used as permitted, each extension cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet.

H. Equipment attached with plug-in cords used in outdoor and/or wet locations shall be protected by GFCIs.

I. All receptacles shall be of the grounding type. All branch circuits shall include a separate equipment grounding conductor, and all receptacles shall be electrically connected to the equipment grounding conductors(s). Receptacles shall not be connected to the same ungrounded conductor of multi-wire circuits that supply temporary lighting.

J. Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

K. All lamps for general illumination shall be protected from accidental contact or breakage by a suitable luminaire or lamp holder with a guard.

L. Cable assemblies and flexible cords and cables shall be supported in place at intervals that ensure they will be protected from physical damage. Support shall be in the form of staples, cable ties, straps, or similar type fittings installed so as not to cause damage.

M. Electrical hand tools and equipment will be to the following standards:
   1. Where possible, hand tools will be of 110 or 120 V.
   2. Where 240 V tools are used, they will be double insulated.
   3. Equipment casing will be intact with no loose fittings or exposed cables.
   4. Plug fittings will be of an approved industrial type.
   5. The tool will be in good condition and will be subject to preventative maintenance schedules recommended by the manufacturer.

3.12 Inspection of Powered Hand Tools

A. All required tests shall be performed before first use; before equipment is returned to service following any repairs; before equipment is used after any incident which can be reasonably suspected to have caused damage (e.g., when a cord set is run over); and at intervals not to exceed three months.

B. If any of the conditions listed below exist, the equipment must be tagged with a “DO NOT USE” tag and returned to the tool crib for repair or disposal:
   1. Breaks, damage, or cracks exposing energized electrical parts
   2. Missing cover plates
   3. Terminations with stray strands or loose terminals
   4. Missing, loose, altered, or damaged blades, pins, or contacts
   5. Frayed or damaged cords
   6. Incorrect polarity

C. Double insulated tools (tools without a manufacturer ground) shall:
   1. Have a visual inspection before use
   2. Be inspected quarterly by qualified electrician

3.13 Ground Fault Circuit Interrupter

A. The following requirements pertain to the location and recommended use of a ground fault circuit interrupter (GFCI):
   - According to applicable codes/standards, GFCIs will be provided for all 120 V, single-phase, 15- and 20-amp (A) receptacle outlets (or 240 V, single-phase, 30 and 40 A, as applicable) that are not part of the permanent wiring of a building or structure (e.g., temporary wiring during construction), unless assured grounding is used.
   - GFCIs will be provided for lavatory, washroom, and change room outlets.
   - GFCIs will be provided for all areas having a moist or wet atmosphere where electrical equipment or portable electric tools may be used.

B. There are certain limitations associated with the use of GFCIs. These limitations include the following:
   - GFCIs operate only on line-to-ground fault currents, such as insulation leakage currents or currents likely to occur during accidental contact with an energized wire of a 120 V circuit and ground. GFCIs do not protect in the event of line-to-line contact.

- It is essential that the polarity of conductors in all cords, plugs, and receptacles supplying single-pole portable GFCI units be properly maintained or the unit may not protect personnel against shock.
- It is generally desirable to locate portable GFCI units near the equipment being used and to use relatively short cords to each tool or lamp. This may minimize nuisance tripping.

C. GFCI testing requirements include, at a minimum, the following:
- All GFCIs will be inspected and checked on a quarterly basis in accordance with ML-SH-801768-A001, *UPF Color Code List for Documentation of Inspections*.
- Documentation will be maintained by the Electrical Department.

3.14 Inspection of Protective Equipment

A. Insulating equipment shall be inspected by the assigned employee for damage before each day's use and immediately following any incident that can reasonably be suspected to have caused damage. Insulating gloves will be given an air test by blowing into the glove and sealing off the top of the glove and inspecting for cuts, tears, holes, or air leakage before use.

B. Insulating equipment with any of the following defects may not be used:
1. A hole, tear, puncture, or cut
2. Ozone cutting or ozone checking (the cutting action produced by ozone on rubber under mechanical stress into a series of interlacing cracks)
3. An embedded foreign object
4. Any of the following texture changes: swelling, softening, hardening, or becoming sticky or inelastic
5. Any other defect that damages the insulating properties

C. Repaired insulating equipment shall be tested again before it may be used by employees, to show that it can withstand the voltage for which it is intended to be used.

D. Insulating equipment must be tested in accordance with 29 CFR 1910.137. Equipment will be stamped/tagged with the date it was tested, the class of the equipment, and the test voltage.

E. Test equipment and accessories are labeled and rated for the voltages and other limits that apply. The items are tested and certified on a periodic basis in accordance with NFPA 70E.

3.15 Electrical Power and Lighting Circuits

A. Switches and breakers used for the routine opening and closing of circuits under loads shall be load rated.

B. After a circuit has been de-energized by the operation of an over-current device, the circuit may not be manually energized until it has been determined by a qualified electrician or electrical supervisor that it is safe to do so, with the following exception:
- 110 V, 15- and 20-ampere (amp) breakers may be reset ONCE by operators. If the breaker trips again, it must be evaluated by qualified electrical personnel.

C. Circuit breaker panels, transformers, and switchgear shall be labeled to show the voltage involved.

D. Source disconnect locations shall be identified on all receptacles, disconnects, and light fixtures.

E. Circuit breaker panels shall be labeled to show what each breaker energizes.

F. Test instrument equipment and accessories shall be rated for the circuits and equipment to which they will be connected.

G. Electrical panel boxes (usually kept closed) may be left open when a LOTO device that has been attached to a circuit breaker holds a door open so that it cannot be closed.

3.16 Use of Proximity Testers

In specific instances, the proximity sensor may also be used by qualified electricians for zero energy checks in electrical switchgear only at voltages of 480 VAC and greater. Prior to use in these instances, the qualified electrician must meet the requirements in this manual. For voltages under 480 VAC, the proximity tester will not be used and does not meet the requirements for zero energy check or verification under Y17-95-64-801, *UPF Construction Phase System and Equipment Safety Lockout/Tagout*. The proximity tester may be used by a qualified electrician as a personal verification tool. When used for trouble shooting circuits, a multi-meter shall be used to verify the proximity tester results. Prior to being issued a proximity sensor, personnel will be trained on the proper use and limitations of the proximity sensor that will be issued by the tool room. Personal proximity sensors are not authorized for use on UPF. The proximity sensor will be issued only to qualified electricians after having the appropriate training, that training is documented (by the authorized trainer sending an email to the Tool Room and ES&H) adding the person to the competent persons' list.

3.17 UPF-Authorized Inspectors

3.17.1 Authority Having Jurisdiction

The person referred to as the Authority Having Jurisdiction (AHJ) is responsible for enforcing the requirements of a code or standard, approving equipment, materials and installation and who interprets the electrical requirements of OSHA, *National Fire Protection Association*, NFPA 70 and 70E, and other electrical standards applicable to the site and its facilities.

3.17.2 Owner's Inspector

The Consolidated Nuclear Security, LLC (CNS) Owner's Inspector (OI) refers to the CNS employee with overall responsibility to review, approve, and execute the UPF OI program by ensuring to the extent necessary, that electrical components and systems are installed, fabricated, and tested in accordance with the requirements of the Code and engineering design documents. The CNS OI meets the code-specified qualifications required to perform this function.

3.17.3 UPF Owner's Inspector Delegate

To be nominated to be a UPF Owner's Inspector Delegate (OID), one must be a Bechtel National, Inc. (BNI) employee who has a minimum of five years combined schooling/experience with electrical/electronic system design and/or electrical system construction/installation/inspection. The employee must complete the current NFPA 70 training every three years. They must also complete the International Code Council (ICC) certification for Commercial Electrical Inspector or International Association of Electrical Inspectors (IAEI). The OID must verify, inspect and document that all applicable requirements of the Code and of the engineering design have been met. The OID will be nominated for approval by the Project Field Engineer and approved by the AHJ using CFN-1261, *UPF Electrical Owner Inspector Delegate Form.*

3.17.4 Rights of the Owner's Inspector

The CNS OI and the UPF OIDs shall have access to any area where work concerned with electrical installation is being performed. They shall have the right to audit any examination, to inspect electrical commodities using any examination method specified by the engineering design, and to review all certifications and records necessary to satisfy the owner's responsibilities.

4.0 RECORDS

Records generated by this manual shall be maintained in accordance with Y15-95-800, *UPF Document Management*. Record types for documents submitted to the UPF DMC are identified in ML-PS-801768-A001, *Uranium Processing Facility Project Master Document Type List*. Quality Type is listed as Quality-Lifetime (QA-L), Quality-Nonpermanent (QA-NP), or Non-Quality (Non-QA).

Records generated during the performance of this manual include:

Record Number	Record Title	Record Holder	System/ Location	Quality Type
CFN-1232	Energized Electrical Work Permits (EEWPs)	UPF DMC	InfoWorks	QA-L
CFN-1261	UPF Electrical Owner Inspector Delegate Form	UPF DMC	InfoWorks	QA-L

5.0 REFERENCES

5.1 Source References

24915-000-2KP-A03-00012, *Records Retention and Turnover*

24915-000-4MP-T81-03314, *Work On or Near Energized Circuits*

Nuclear, Security and Environmental (NS&E), ES&H Manual, 45-6BH-F0801, NS&E 226, *Electrical Equipment and Assured Grounding*

NS&E, ES&H Manual, NS&E 234, *Utilities Clearance*

5.2 Interfacing References

29 CFR 1910.137, *Electrical Protective Equipment*

29 CFR 1910.147, *Control of Hazardous Energy (Lockout/Tagout)*

29 CFR 1910.269, Appendix B, *Working on Exposed Energized Parts*

29 CFR 1910.303, *General*

29 CFR 1910.304, *Wiring Design and Protection*

29 CFR 1910.305, *Wiring Methods, Components, and Equipment for General Use*

29 CFR 1910.332, *Training*

29 CFR 1910.333, *Selection and Use of Work Practices*

29 CFR 1926, Subpart K, *Electrical*

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

ML-PS-801768-A001, *Uranium Processing Facility Project Master Document Type List*

ML-SH-801768-A001, *UPF Color Code List for Documentation of Inspections*

NFPA 70, *National Electrical Code (NEC)*

NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*

UL 943, *Standard for Ground-Fault Circuit-Interrupter*

UPF-CP-200, *UPF General Safe Work Practices*

UPF-CP-214, *Barricades and Signs*

UPF-CP-227, *Safety Watches*

Y15-95-800, *UPF Document Management*

Y17-95-64-801, *UPF Construction Phase System and Equipment Safety Lockout/Tagout*

Y17-95-64-822, *UPF Site Excavation and Backfill*

Y17-95-64-871, *UPF Construction Hoisting and Rigging Operations*

6.0 SUPPLEMENTAL INFORMATION

Appendix A, *Acronyms and Definitions*

Appendix B, *Electrical Safety Requirements*

Appendix C, *Protective Clothing and Personal Protective Equipment*

Appendix D, *Flash Protection Boundary Distance Calculations*

Appendix E, *Energized Electrical Work Permit Instructions*

APPENDIX A
Acronyms and Definitions
(Page 1 of 6)

ACRONYMS:

AHJ	Authority Having Jurisdiction
ALA	Absolute Limit of Approach
amp	ampere
ATPV	arc thermal performance exposure value
BNI	Bechtel National, Inc.
B/SO	buddy/safety observer
cal/cm^2	calories per square centimeter
CFR	Code of Federal Regulations
CM	Construction Manager
CNS	Consolidated Nuclear Security, LLC
DS	Discipline Superintendent
EEWP	energized electrical work permit
ES&H	Environment, Safety, and Health
°F	degrees Fahrenheit
FPB	flash protection boundary
FR	fire resistant
ft	foot
GFCI	ground fault circuit interrupter
IAEI	International Association of Electrical Inspectors
IEEE	Institute of Electrical and Electronics Engineers
ICC	International Code Council
in.	inch
JHA	Job Hazard Analysis
kV	kilovolt
LAB	limited approach boundary
LOTO	lockout/tagout
mA	milliampere
MCC	motor control center
N/A	not applicable
NFPA	National Fire Protection Association

APPENDIX A
Acronyms and Definitions
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OI	Owner's Inspector
OID	Owner's Inspector Delegate
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
RAB	Restrictive Approach Boundary
S&H	safety and health
STARRT	safety task analysis and risk reduction talk
UPF	Uranium Processing Facility
V	volt
VAC	volt alternating current
VDC	volt direct current

DEFINITIONS:

Ampere (Amp)	A unit for measuring the rate at which electric current flows. Amperage is the strength of a current of electricity expressed in amperes.
Assured Equipment Grounding Conductor Program	The process of testing electrical tools and extension cords to assure their proper grounding, polarity, and resistance.
Buddy/safety observer (B/SO)	A second qualified electric person who is required to be present and within the immediate area at all times while work is being performed on potentially energized electrical equipment at 50 V or more. The B/SO must know which breaker to open if it becomes necessary to shut off the power.
Electrical equipment	Any equipment that could require employees to work near exposed electrical conductors, buses, terminations, or other surfaces that may be energized. The equipment's electrical sources and circuits are locked out and tagged out in the de-energized position. Other methods may be used in conjunction with electrical de-energization and lockout/tagout (LOTO), but not in substitution. A piece of equipment or machinery capable of being locked out uses a lockout method, not a tagout method.

APPENDIX A
Acronyms and Definitions
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Electrical hazard	A dangerous condition in which contact by employees, or equipment failure, can result in electric shock, arc flash burn, thermal burn, or blast from an energy source greater than 50 V.
Electrically safe work condition	A state in which a worker is able to work safely on or near an electrical conductor or circuit part because the conductor or circuit part has been disconnected from energized parts, locked out or tagged out in accordance with established standards, tested to ensure the absence of voltage (i.e., "zero energy"), and grounded if determined necessary.
Energized electrical work	Any work on exposed non-insulated parts involving more than 50 V where a shock hazard exists. De-energized circuits in close proximity to live unprotected circuits shall be treated as energized circuits. When the plane of the front of an electrical panel or other enclosure is broken and it has exposed energized circuits in it, all of the wiring shall be treated as if it were energized.
Exclusive control	Under the exclusive control of the employee means that the authorized employee is continuously in physical possession of the de-energized machine or equipment being serviced or maintained (or within arm's reach of the cord/plug AND the cord/plug is within 5 feet (ft) line of sight of the authorized employee) to prevent other individuals from reenergizing the machine or equipment. Exclusive control shall only be used in instances where the cord/plug is the only energy source to the machine or equipment. It may be used for calibration and pressure indicator change-out. Any other applications or work scenarios shall be evaluated and approved by the ES&H Department on a case-by-case basis.
Exposed	(As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by any individual. This term is also applied to parts not suitably guarded, isolated, or insulated.
Exposed fixed circuit part	A fixed circuit part refers to a task in which the conductor is not expected to move (e.g., within a unit substation).
Exposed movable conductor	Intended to mean that either the conductor might move (as in an overhead line) or the person might move (as in an articulating support platform).

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Acronyms and Definitions
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Flash protection boundary (FPB) = Restricted Approach Boundary (RAB)	An approach limit that specifies a distance from exposed live parts, within which a person could receive a second-degree burn if an electrical arc flash were to occur. The FPB is the distance from the arc source (energized exposed equipment) at which the potential incident heat energy from an arcing fault falling on the surface of the skin is 1.2 calories per square centimeter (cal/cm^2). An exposure to 1.2 cal/cm^2 would ordinarily result in a curable second-degree burn. Within this boundary, employees are required to wear protective clothing like fire resistant (FR) shirts, pants, and other equipment to cover various parts of the body. This distance may vary from equipment to equipment since it is a function of the available fault current of the system at that point, the voltage, and the tripping characteristics of the upstream protective device.
Flash suit	This is a complete FR clothing and equipment system that covers the entire body except for the hands and feet. The system includes pants, a jacket, and a beekeeper-type hood fitted with a face shield.
Ground fault circuit interrupter (GFCI)	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 (fault) exceeds the values established for a Class A device. According to UL Standard 943, *Ground-Fault Circuit-Interrupters*, a Class A GFCI trips when the current-to-ground has a value in the range of 4 to 6 milliamperes (mA).
Guarded	Electrical equipment or components are covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms that remove the likelihood of approach or contact by persons or objects to a point of danger.
Heavy Equipment	Equipment powered by internal combustion engines (Diesel, Gasoline and Liquid Propane Gas), which is self-propelled or mobile construction equipment, such as mobile cranes, dozers, scrapers, excavators, graders, dump-bed trucks (single, dual, and tri-axle), or vehicles designed to move or lift heavy loads or supply heavy driving force.
Limited approach boundary (LAB)	An approach limit that specifies a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists; it is not to be crossed by unqualified persons unless escorted by a qualified person.

APPENDIX A
Acronyms and Definitions
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Lockout/tagout (LOTO)	The placement of a lock and tag on an energy-isolating device to prevent the unexpected energizing, start-up, or release of stored energy from equipment or machines that could cause injury to employees. Methods of LOTO include a) locking and tagging the entire electrical supply or individual switches, or b) locking or blocking internal moving parts in resting position, or conducting both a) and b) if the potential exists that performing one or the other does not control all energy sources.
Qualified electrical person	A qualified person trained and knowledgeable of the construction and operation of equipment or a specific work method, and trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Qualified personnel are specifically trained in the requirements contained in NFPA 70E and 29 CFR 1910.332. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment (PPE), insulating/shielding materials, and insulating tools and test equipment. Qualified persons permitted to work within limited approach boundaries (LABs) of exposed energized conductors and circuit parts shall, at a minimum, be additionally trained in all of the following: • The skills and techniques necessary to distinguish exposed energized electrical parts from other parts of electrical equipment • The skills and techniques necessary to determine the nominal voltage of exposed energized parts • The approach distances specified in Table 1 and Table 2 in Section 5.2 and the corresponding voltages to which the qualified person will be exposed • The decision-making process necessary to determine the degree and extent of the hazard, and the PPE and job planning necessary to perform the task safely An employee who is undergoing on-the-job training and, in the course of such training, has demonstrated an ability to perform duties safely commensurate with the level of training received under the direct supervision of a qualified person shall be considered to be a qualified person for the performance of those duties.
Restricted approach boundary	An approach limit that specifies a distance from an exposed energized electrical conductor or circuit part within which there is an increased risk of shock due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit part; it is to be crossed by only qualified persons.

APPENDIX A
Acronyms and Definitions

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Single-Phase	Of or designating an electrical circuit having an alternating current with one phase.
Work near (live parts)	Any work activity inside a LAB.
Work on (energized electrical conductors or circuit parts)	Coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools or probes, or with test equipment, regardless of the PPE worn.
Work site	The barricaded area immediately adjacent to the location where the physical work is being performed.
Zero energy testing	A task performed only by a qualified electrical person to test de-energized and isolated conductors and circuit parts. The qualified electrical person will verify proper operation of the test equipment before and after use. The task is to prove that conductors and circuit parts are free from any connection to a voltage source and that no residual or stored electrical charge is present within the defined boundaries of the equipment or system being worked on. The qualified electrical person performing the test also ensures that grounding measures have been installed if required. Thorough and successful zero energy testing enables the LOTO to be completed for the isolation points defined for the equipment or system via its LOTO form. Once the LOTO form is completed and signed by the qualified personnel, the level of electrical safety PPE required for this testing can be reduced as long as the installed LOTO remains in place and the associated conditions and equipment do not change in any way.

APPENDIX B
Electrical Safety Requirements

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B1. 50 V to 150 V Line-to-Ground to 250 V Line-to-Line Alternating Current or Direct Current

Work Description	Test Equipment			Tools		Safety Requirements and Protective Equipment		Approval	Attendance		B/SO		Flash Protection Category
	Approved Multimeter	Clamp Amp Meter	Other Approved Instrumentation	Fuse Puller	Insulated Hand Tools	Safety Glasses	Low-Voltage Gloves	Supervisor	Attendance Required?	B/SO	Low-Voltage Gloves	Safety Glasses	
Voltage, Current Reading	X	X	X			X	X	X	No				N/A
Fuse Pulling under 20 amp				X		X	X	X	No				N/A
Lead Lifting under 20 amp					X	X	X	X		X	X	X	N/A
Probing					X	X	X	X		X	X	X	N/A

X = Required; N/A = Not applicable

Any deviations require approval by the CM and the ES&H Manager, or their designees.

APPENDIX B
Electrical Safety Requirements
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B2. 150 V Line-to-Ground to 600 V Line-to-Line Alternating Current or Direct Current

	Test Equipment			Tools			Safety Requirements and Protective Equipment					Approval			Attendance			B/SO		
Work Description	**Approved Multimeter**	**Clamp Amp Meter**	**Other Approved Instrumentation**	**Fuse Puller**	**Breaker Jacking Tools**	**Insulated Hand Tools**	**Safety Glasses**	**Face Shield**	**Insulated Shepherd's Hook**	**Low-Voltage Gloves**	**Rubber Mat**	**Electrical Supervisor**	**Supervisor**	**Maintenance Manager**	**Attendance Required?**	**B/SO**	**Electrical Supervisor**	**Low-Voltage Gloves**	**Safety Glasses**	**Flash Protection Category**
Probing						X	X	X		X	X		X			X		X	X	2
Voltage, Current Reading	X	X	X				X	X		X	X		X			X		X	X	2
Pulling Control Fuses or Fuses at No Load				X			X	X		X	X		X			X		X	X	0–1
Pulling or Inserting Plug-In Devices on Energized Motor Control Centers (MCCs)						X	X	X		X	X	X				X	X	X	X	3
Jacking Breakers In/Out on Energized MCCs					X		X	X		X			X		No				X	2–3
Other Work, Energized Circuits	X		X			X	X	X	X	X	X	X		X		X		X	X	2

X = Required

Any deviations require approval by the CM and the ES&H Manager, or their designees.

APPENDIX B
Electrical Safety Requirements
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B.3 601 V to 15,000 V Line-to-Line Alternating Current

	Test Equipment				Tools			Safety Requirements and Protective Equipment						Approval		Attendance	B/SO		
Work Description	**Megger Meter**	**High-Volt Detector**	**Hi Pot**	**Other Approved Instrumentation**	**Breaker Jack Tools**	**High-Voltage Fuse Puller**	**High Stick, 5' Minimum**	**Safety Glasses**	**Face Shield**	**LOTO**	**High-Voltage Gloves**	**Sleeves**	**Rubber Mat**	**Electrical Supervisor**	**Supervisor**	**B/SO**	**High-Voltage Gloves**	**Safety Glasses**	**Flash Protection Category**
Voltage Reading		X		X				X	X		X	X	X	X	X		X	X	3
Jacking Breakers In/Out on Energized MCCs					X			X	X		X	X			X	X	X	X	2–3
Hi Potting, Deenergized Equipment			X					X		X	X	X	X	X	X		X	X	1
Pulling Fuses, No Load						X	X	X			X	X	X	X	X		X	X	1
Insulation Testing and Megger	X							X		X					X			X	1

X= Required

Any deviations require approval by the CM and the ES&H Manager, or their designees

APPENDIX B
Electrical Safety Requirements

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B.4 50 V to 150 V Line-to-Ground to 250 V Line-to-Line Alternating Current or Direct Current

Work Description	Test Equipment	Tools	Safety Requirements and Protective Equipment				Approval	Attendance		B/SO		Flash Protection Category
	Other Approved Instrumentation	Insulated Hand Tools	Face Shield	LOTO	Apron	Gloves	Supervisor	Attendance Required?	B/SO	Gloves and Apron	Face Shield	
Voltage and Specific Gravity Readings	X		X		X	X	X	No				0
Battery Rundowns	X	X	X	X	X	X		No				0
Equalize	X		X		X	X	X	No				0
Torque Bolts, Lifting Leads		X	X	X	X	X	X		X	X	X	0

X= Required

Any deviations require approval by the CM and the ES&H Manager, or their designees.

APPENDIX C
Protective Clothing and Personal Protective Equipment

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C1. Protective Clothing Characteristics

Hazard Risk Category	Clothing Description	Minimum Arc Thermal Performance Exposure Value (ATPV) Rating of PPE (cal/cm^2)
0	Untreated cotton	N/A
1	FR coveralls	4
2	Cotton underwear plus FR coveralls	8
3	Cotton underwear plus flash suit and hood	25
4	Cotton underwear plus FR coveralls plus flash suit and hood	40

Any deviations require approval by the CM and the ES&H Manager, or their designees.

APPENDIX C
Protective Clothing and Personal Protective Equipment

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C.2 Protective Clothing and Personal Protective Equipment Flash Protection Criteria

Hazard Risk Category Number	1	2	3	4
Untreated Natural Fiber				
Shirt (long sleeve)	X	X	X	X
Pants (long)	X [1]	X [2]	X	X
Underwear [3]	X	X	X	X
Fire-Rated Clothing [4]				
Coveralls (“Greens”) Preferred [5]	X	X	X [6]	X
Jacket, parka, or rainwear	AN	AN	AN	AN
Fire-Rated Protective Equipment				
Flash suit jacket (two layers)			X	X
Flash suit pants (two layers)			X	X
Head Protection				
Hard hat	X	X	X	X
Fire-rated hard hat liner			X	X
Eye Protection				
Safety glasses	X	AL	AL	AL
Safety goggles			AL	AL
Face shield	X	X		
Face protection double-layer switching hood	X	AR [7]	X	X
Hearing Protection				
Ear canal inserts		AR [7]	X	X
Other				
Leather gloves [8]	AN	X	X	X
Leather work shoes	AN	X	X	X

Any deviations require approval by the Site Manager and the ES&H Manager, or their designees.

Legend:

AL = Select one in group AN = As needed AR = As required X = Minimum required

APPENDIX C
Protective Clothing and Personal Protective Equipment

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C.2 Protective Clothing and Personal Protective Equipment Flash Protection Criteria

Notes:

[1] Regular weight (minimum 12 oz/yd^2 fabric weight), untreated denim cotton blue jeans are acceptable in lieu of fire-rated pants. The fire-rated pants used shall have a minimum ATPV of 5.
[2] Alternative is to use fire-rated coveralls (minimum ATPV of 5) over untreated natural fiber pants and T-shirt.
[3] All underwear must be 100% natural fiber or fire rated. A small amount of elastic used on undergarments shall be permitted.
[4] See Appendix B1 (ATPV in cal/cm^2).
[5] Alternative is to use fire-rated shirt and fire-rated pants (minimum ATPV of 5) instead of fire-rated coveralls.
[6] Flash suit with flash hood is the preferred PPE. Alternative is to use two sets of fire-rated coveralls (each with a minimum ATPV of 5) over untreated natural fiber clothing, instead of fire-rated coveralls over fire-rated shirt and fire-rated pants over untreated natural fiber clothing.
[7] A double-layer switching hood and hearing protection are required for these tasks.
[8] If voltage-rated gloves are required, the leather protectors worn externally to the rubber gloves satisfy the requirement.

APPENDIX D
Flash Protection Boundary Distance Calculations

600 V and below:

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$$

or

$$D_c = [53 \times MVA \times t]^{1/2},$$

where

D_c = Distance of person from an arc source in feet

MVA_{bf} = Bolted fault MVA at point involved

MVA = MVA rating of transformer
(For transformers with MVA rating below 0.75 MVA, multiply the transformer MVA rating by 1.25.)

t = Time of arc exposure in seconds

Above 600 V:

At voltage levels above 600 V, the FPB is the distance at which the incident energy level equals cal/cm^2. For situations in which the fault clearing time is 0.1 second (or faster), the FPB is the distance at which the incident energy level equals 1.5 cal/cm^2.

APPENDIX E
Energized Electrical Work Permit Instructions

The log for *Energized Electrical Work Permit (EEWP)* form *CFN-1232* shall be maintained by the System Engineer or designee.

A. EEWP Preparation

1. The EEWP requestor (either the System Engineer or Subcontractor Technical Representative) shall fill out section 1 of the EEWP.
2. The EEWP requestor shall identify the employees to perform the planned work and ensure they are qualified to perform the work on or near exposed live parts (qualified electrical persons).
3. The EEWP requestor shall sign the permit and obtain the appropriate signatures and then forward the form to the System Engineer (or designated individual) for logging.

B. The System Engineer shall ensure the EEWP was logged and shall review the EEWP to determine whether the EEWP contains a justification that meets the criteria. If so, and if no other issues to the contrary exist, the Field Engineer signs section 1 of the EEWP and then completes section 2 of the EEWP.

C. The System Engineer enters the permit effective date range. No work authorized by the EEWP shall be performed outside of the permit effective date range.

D. The Department Manager and the ES&H Representative, or their designees as appropriate, review the EEWP and sign section 3 to authorize the planned work.

E. Once the EEWP is authorized to perform the work, the System Engineer conducts a pre-job brief. The Field Engineer notifies the person in charge of the work area and work operation covered by the EEWP. The required STARRT cards and/or JHAs shall be developed and/or reviewed by the assigned employees.

F. Section 4 of the EEWP shall be completed by the System Engineer as a supplement to the STARRT card when applicable. The Field Engineer retains the original EEWP until the permit is closed, and the EEWP is kept with the applicable STARRT card at the work location for the duration of the work activity.

G. Closed EEWPs shall be returned to the System Engineer, or designee, for filing into infoworks.