West Chester University Electrical Safety Program

Purpose

The purpose of this policy is to establish safe work practices that are intended to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts when work is performed near or on equipment or circuits which are or may be energized and to comply with the OSHA Standard on electrical safe work practices 29 CFR 1910.301 through 1910.335.

Scope

A. This policy applies to both Qualified persons and Unqualified persons who are working on, near, or with the following electrical installations:

1. Premises Wiring. Installations of electrical conductors and equipment within or on buildings or other structures, and on other premises such as yards, carnival, parking and other lots and industrial substations

2. Wiring for Connection to Supply. Installations of conductors that connect to the supply of electricity

3. Other Wiring. Installations of other outside conductors on the premises

4. Optical Fiber Cable. Installations of optical fiber cable where such installations are made along with electrical conductors

5. Exposed Energized Parts. Installations that involve work performed by unqualified persons on or near exposed energized parts.

Definitions

A. Qualified Person -means a person permitted to work on or near exposed energized parts who has been trained in and familiar with:
   1. The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment

   2. The skills and techniques necessary to determine the nominal voltage of exposed live parts

   3. The knowledge, skills and techniques to work safely on energized circuits

4. The proper use of special precautionary techniques, personal protective equipment, Insulating and shielding materials, and insulated tools

5. The clearance distances for work performed near overhead lines that are specified in the OSHA standard that appears in 29 CFR 1910.333(c) and the corresponding voltages to which the person will be exposed.

B. Unqualified Person - means a person with little or no training in avoiding the electrical hazards of working on or near exposed energized parts.

C. On or Near- means close enough to exposed line parts (by either personal contact or contact by tools or materials) for an employee to be exposed to any hazard they present.

Responsibility for Compliance

A. The Office of Environmental Health and Safety
   1. EH&S shall ensure the Electric Safety Program is reviewed, maintained, and updated.

   2. EH&S will, if necessary, provide recommendations for additional control methods to be used in areas were deemed necessary to protect employees from electrical hazards.

   3. Assist shops in implementing the provisions of this program.

   4. Provide or assist in task specific training for electrical work qualifications.

   5. Evaluate overall effectiveness of the WCU electrical safety program.

B. Department Managers

   1. Monitor this Electrical Safety Program. Questions regarding this program and any information associated with it should be directed to the EHS.

   2. Ensure that all employees are properly trained for the tasks they will perform.
   3. Participate in the approval of all energized work and preparation of the Energized
   4. Electrical Work Permit required for work to begin.
   5. With the assistance of the supervisor and/or their designees and the Electrical Safety
   6. Ensure the preventative maintenance programs are in place to properly maintain electrical equipment pursuant the OEM recommendations of NFPA 70B

C. Supervisors

1. Determine the applicability of this program to applied activities within their respective areas.

2. Coordinate the implementation of the electrical safety program within their areas.

3. Ensure employees comply with all provisions of this program.

4. Ensure employees receive training appropriate to their assigned electrical tasks and maintain documentation of such training.

5. Ensure that all electrical equipment is maintain pursuant the manufactures recommendation or NFPA 70B in the absence of documentation from the manufacture

6. Ensure employees are provided with and use appropriate PPE.

D. Employees

1. Follow the work practices described in this program, including the use of appropriate protective equipment and tools.

2. Do not perform tasks unless the proper training has been provided.

3. Attend all training required relative to this program.

4. Report any concerns related to electrical safety to supervision.

General Requirement

Appropriate safe work practices will be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts when work is performed near or no equipment or circuits that are or may be energized. Those specific work practices will be consistent with the nature and extent of the associated electrical hazards.

Hazard Elimination

Hazard elimination shall be the first priority in the implementation of safety related work practices. Once a hazard has been identified, it should be determined if the hazard can be eliminated. During the electrical system design stage, methods should be employed to eliminate hazards in their entirety.

Engineering Controls

A. All electrical distribution panels, breakers, disconnects, switches, junction boxes, etc. shall be completely enclosed.

B. A watertight enclosure shall be used where there is the possibility of moisture entry either from operations or weather exposure.

C. Electrical distribution areas will be guarded against accidental damage by locating in specifically designed rooms, use of substantial guard posts and rails and other structural means.

D. Electrical distribution rooms, vaults and spaces shall be so enclosed within fences, screens, partitions, or walls as to minimize the possibility that Unqualified Persons will enter.

E. Entrances to electrical distribution rooms, vaults and spaces that are not under the observation of an attendant shall be kept locked.

F. Sufficient access and working space shall be provided and maintained around electrical equipment to permit ready and safe operation and maintenance of such equipment. A clear approach and 3-feet of side clearance shall be maintained for all distribution panels.

G. All conduits shall be fully supported throughout its length. Non-electrical attachments to conduit are prohibited.

H. All non-rigid cords shall be provided strain relief where necessary.

Administrative Controls

A. Signs warning Unqualified Persons to keep out of electrical distribution rooms, vaults and spaces shall be displayed at entrances.

B. Unqualified Persons may not enter electrical distribution rooms, vaults, and spaces where there are energized, exposed electrical conductors or circuit parts.

C. Access to electrical distribution rooms, vaults and spaces is limited to those employees who have a need to enter.

D. Only Qualified Persons shall conduct diagnostics and repairs to electrical equipment.

E. Contractors performing electrical work must hold a license for the work.

F. Areas under new installation or repair will be sufficiently guarded with physical barriers and warning signs to prevent unauthorized entry.

G. All electrical control devices shall be properly labeled.

H. All Qualified Persons shall follow established electrical safety and standard operating procedures.

I. Conductive articles of jewelry and clothing (such a watch bands, bracelets, rings, key rings, necklaces, metalized aprons, cloth with conductive thread, or metal headgear) may not be worn if they might contact exposed energized parts. Articles may be worn if they are rendered nonconductive by covering, wrapping, or other insulating means.

J. When normally enclosed live parts are exposed for maintenance or repair, they will be guarded to protect unqualified persons from contact with their live parts.

K. Alerting techniques will be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts as follows:
    1. Safety Signs and Tags: Safety signs, safety symbols, or accident prevention tags will be used where necessary to warn employees about electrical hazards which may endanger them.

    2. Barricades: Barricades will be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.

    3. Attendants: If signs and barricades do not provide sufficient seaming and protection from electrical hazards, an attendant will be stationed to warn and protect employees.

Risk Assessment Procedure

A. The intent of this procedure is to perform a risk assessment, which includes a review of the electrical hazards, the associated foreseeable tasks, and the protective measures that are required in order to maintain a tolerable level of risk. This includes the following before work is started:
    1. Identify the electrical hazards.
    2. Assess the risk by identifying and analyzing the tasks to be performed.
    3. Implement risk control by determining the appropriate protective measures.

B. See Appendix 1 for sample risk assessment procedures.

Energized Electrical Work Policy

A. It shall be West Chester University's practice to perform electrical work on de-energized systems.
    1. See Lock Out/Tag Out Program

B. There may be rare circumstances that necessitate work on energized systems. This may be the case if de-energizing introduces additional or increased hazards or infeasibility due to equipment design or operational limitations including testing of electric circuits that can only be performed with the circuit energized.

C. Justification for energized work must be provided and include the following:
    1. The appropriate job hazard/risk analysis.

    2. Workers and supervisory staff acknowledge they are "qualified" for the task(s).

    3. The work can be conducted safely.

    4. Proper safety planning and preparation occurs.

    5. Proper personal protective equipment (PPE) is utilized.

D. Applicable documents may include, but not be limited to the Arc and Shock Hazard Risk Assessments, Job Planning & Briefing Checklist and Energized Electrical Work Permit.

E. This program applies to all faculty and staff who perform work on electrical circuits and equipment operating at voltages 50 volts and above. Voltage below this is permitted to be worked on "live" if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Establishing an Electrically Safe Condition

(See Lock Out/Tag Out Program)

A. Working On or Near Electrical Equipment (De-energizing Equipment)
    1. Energized parts to which one might be exposed, shall be put into an electrically safe work condition before working on or near them, unless work on energized components can be justified.

    2. If equipment is de-energized but not locked and tagged out AND not tested/verified, then it must be considered energized.

    3. Only properly Qualified Persons shall use test equipment to test circuit elements and current carrying parts to verify all circuits and parts are de-energized. Testing shall also determine if any energized conditions exist as a result of induced voltage or unrelated voltage back feed

B. Verification of an Electrically Safe Work Condition (Lockout/Tagout)

1. The procedure to be followed by the Qualified Person working on the circuits is as follows (Utilize the appropriate personal protective equipment and proper voltage-rated tools for these steps):

2. Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

3. After properly interrupting (de-energizing) the load current, open the disconnecting devices for each source.

4. Whenever possible, visually verify that all blades of the disconnecting devices are fully open or that draw out-type circuit breakers are withdrawn to the fully disconnected position.

5. Release stored electrical energy.

6. Release or block stored mechanical energy.

7. Apply lockout/tagout devices in accordance with Lockout/Tagout Program.

8. Verification - Use an appropriately rated and calibrated portable test instrument to test each phase conductor or circuit part to verify it is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on a known voltage source.

9. Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:
    a. Placement – Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard (i.e., hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the job planning.

    b. Capacity – Temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

c. Impedance – Temporary protective grounding equipment and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

C. Process of Reenergizing Equipment
    1. In addition to the requirements of Lockout/Tagout Program, the following requirements must be met, in the order given, before circuits or equipment are re-energized, even temporarily:
        a. A Qualified Person must conduct tests and visual inspections as necessary to verify that all tools, electrical jumpers, shorts, grounds and other such devices have been removed so that circuits and equipment can be safely energized.

        b. Anyone potentially exposed to the hazards of re-energizing the circuit must be warned to stay clear.

        c. Each person removes his or her lock(s) and tag(s).

Work on Exposed Energized Electrical Equipment (Permit Required)

A. Safe work practices shall be used to safeguard individuals from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazards and the associated risk. Appropriate safe work practices shall be determined before any person is exposed to the electrical hazards involved by conducting risk assessments to identify arc flash and shock hazards. Only Qualified Persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.

B. This section is intended to establish the minimum requirements and performance expectations for all Qualified Persons.

C. All, faculty, and staff shall comply with procedures outlined and where necessary, shall supplement requirements as needed to minimize risks and exposure to hazards.

D. A Working on Energized Parts – Energized Electrical Work

E. Justification to work on energized equipment.
    1. Examples of Additional Hazards or Increased Risk:
        a. Interruption of life support equipment.
        b. Deactivation of emergency alarm systems.
        c. Shutdown of hazardous location ventilation equipment.

2. Examples of infeasibility due to equipment design or operational limitation:
    a. Diagnostics and testing/troubleshooting that can only be successfully performed with circuit energized.

    b. Work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

3. Normal Operation – Normal operation of electric equipment shall be permitted where all of the following conditions are satisfied:
    a. The equipment is properly installed.

    b. The equipment is properly maintained.

    c. The equipment is used in accordance with instructions included in the NRTL listing and labeling and in accordance with manufacturer's instructions.

    d. All equipment doors are closed and secured.

    e. All equipment covers are in place and secured.

    f. There is no evidence of impending failure.

F. Energized Electrical Work Permit (See Appendix 3)
    1. When Required **–** When energized work is performed as permitted in accordance with the criteria listed above, an energized electrical work permit shall be required and documented under the following conditions:
        a. When energized electrical work will be performed within the restricted approach boundary.

        b. When the employee may interact with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

    2. The work permit shall include the following items:
        a. Description of the circuit and equipment to be worked on and the location.

        b. Description of the work to be performed

        c. Justification for why the work must be performed in an energized condition

        d. The voltage to which personnel will be exposed

e. Available incident energy at the working distance or arc flash PPE category

f. Determination of shock and arc flash protection boundaries

g. The necessary PPE required to safely perform the assigned task

h. A description of the safe work practices to be used

i. Means used to restrict the access of Unqualified Persons from the work area

j. Typically, this will consist of demarcating the electrical safety boundary by the use of Energized Area Signs and/or Caution Energized Area Tape

k. Evidence of completion of a job briefing, including a discussion of any job specific hazards. (See Appendix 4)

l. Energized work approval signatures.

G. Exemptions to Work Permit
   1. Work performed on energized parts by properly Qualified Persons related to tasks such as testing, troubleshooting, voltage measuring, removal of a panel to observe live equipment, etc. shall be permitted to be performed without an energized electrical work permit, provided appropriate training, safe work practices, and personal protective equipment is provided and used. While a formal permit is not required, the expectation is that the Qualified Person will perform the electrical tasks following all of the safe work practices detailed above.
      a. Examples:
         I. Thermography, ultrasound, and visual inspection up to restricted approach boundary.

         II. Access/egress with no electrical work up to restricted approach boundary.

         III. General housekeeping and miscellaneous non-electrical tasks up to restricted approach boundary

B. Job Safety Planning and Job Briefing
   1. Before starting each job that involves exposure to electrical hazards, the person in charge shall complete a job safety plan and conduct a job briefing with the employees involved.

2. Job Safety Planning - The job safety plan shall be in accordance with the following:
    a. Be completed by a qualified person

    b. Be well documented, including:
        I. A description of the job and the individual tasks

        II. Identification of the electrical hazards associated with each task

        III. A shock risk assessment for tasks involving a shock hazard

        IV. An arc flash risk assessment for tasks involving an arc flash hazard

        V. Work procedures involved, special precautions, and energy source controls

C. Job Briefings
    1. The job briefing shall cover the job safety plan and the information on the energized electrical work permit. Documentation of the briefing shall be maintained on the checklist included in Appendix 4

    2. The person in charge shall conduct a Job Briefing and it shall cover the following subjects:
        a. Hazards associated with the work

        b. Work procedures involved

        c. Special precautions

        d. Energy source controls

        e. Personal protective equipment requirements

        f. What to do/whom to contact in an emergency

    3. Number of Briefings: If the work or operations to be performed during the workday or shift are repetitive and similar, at least one job briefing shall be conducted before the start of the first job or shift. Additional job briefings shall be held if significant changes, which might affect the safety of the individuals involved, occur during the course of the work.

    4. Extent of Briefings: A brief discussion shall be satisfactory if the work involved is routine and if the individuals involved, by virtue of training and experience, can reasonably be expected to recognize and avoid the hazards involved in the job. A more extensive discussion shall be conducted if:

a. The work is complicated or particularly hazardous

b. The persons involved cannot be expected to recognize and avoid the hazards involved in the job

H. Recordkeeping
   1. Records including Energized Electrical Work Permits and associated supporting documents such as the risk assessments and completed Job Planning and Briefing checklist and any safety audit documentation shall be maintained by the group responsible for the work/audit for a period of at least one year for the purpose of program auditing.

I. Observers
   1. During the time that work is being performed on any exposed conductors or exposed parts of equipment connected to energized systems, a Qualified Person must be in close proximity at each work location to:
      a. Act primarily as an observer for the purpose of preventing an accident

      b. Render immediate assistance in the event of an accident

      c. Ensure that Safe Work Practices (see Appendix 6) are followed while performing energized electrical work

Overhead Power Lines and Elevated Work

A. Whenever work is to be performed near overhead lines, the lines will be deenergized and grounded, or other protective measures will be provided before work is started.

B. When overhead lines are to be deenergized, arrangements to deenergize and ground them will be made with the organization that operates or controls the electrical circuits involved.

C. When protective measures are provided such as guarding, isolating, or insulating, those precautions shall prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

D. Only qualified employees will be permitted to install insulating devices on overhead power transmission or distribution lines.

E. Whenever an unqualified employee is working in an elevated position near overhead lines, the location will be such that the person and the longest conductive object he or

she may contact cannot come closer to any unguarded, energized overhead line than the following distances:

1. For voltages to ground 50kV or below - 10ft.(305cm)

2. For voltages to ground over 50kV - 10 ft. (305cm) plus 4 inches (10 cm) for every l0kV over 50kV

F. Whenever an unqualified employee is working on the ground in the vicinity of overhead lines, the person may not bring any conductive object closer to unguarded, energized overhead lines than the distances given in 7.5.

G. For voltages normally encountered with overhead power lines, objects which do not have an insulating rating for the voltage Involved are considered to be conductive.

H. Whenever a qualified person is working in the vicinity of overhead lines, whether in an elevated position or on the ground, the person may not approach or take any conductive object without an approved insulating handle closer to exposed energized parts than that shown in **Table S-5** of 29 CFR 1910.333(c)(3) (ii)(C) (see 7.8.d), unless **one** of the following are met:

1. The person is insulated from the energized part. Gloves, with sleeves, if necessary, rated for the voltage involved, are considered to be insulation of the person from the energized part on which work is performed

   OR

2. The energized part is insulated both from all other conductive objects at a different potential and from the person

   OR

3. The person is insulated from all conductive objects at a potential different from that of the energized part.

4. The minimum safe approach distances are as follows:

Table S-5
APPROACH DISTANCES FOR QUALIFIED EMPLOYEES
ALTERNATING CURRENT

Voltage Range (Phase to Phase)	**Minimum Approach Distance**

300V and less	Avoid Contact
Over 300V, not over 750 V	1 ft. 0 in. (30.5 cm)
Over 750V, not over 2kV	1 ft. 6 in. (46 cm)
Over 2kV, not over 15kV	2 ft. 0 in. (61 cm)
Over 15kV, not over 37kV	3 ft. 0 in. (91 cm)
Over 37kV, not over 87.5kV	3 ft. 6 in. (107 cm)
Over 87.5V, not over 121kV	4 ft. 0 in. (122 cm
Over 12lkV, not over l40kV	4 ft. 6 in. (137 cm)

I. Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines will be operated so that a clearance of 10 ft. (305 cm) is maintained. If the voltage is higher than 50kV, the clearance will be increased 4 in. (10 cm) for every l0kV over that voltage. However, under any of the following conditions, the clearance may be reduced:
    1. If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 ft. (122 cm). If the voltage is higher than 50kV, the clearance will be increased 4 in. (10 cm) for every 10kV over that voltage.

    2. If insulating barriers are installed to prevent contact with the lines, and if the barriers are rated for the voltage of the line being guarded and are not a part of or an attachment to the vehicle or its raised structure, the clearance may be reduced to a distance within the designed working dimensions of the insulating barrier.

    3. If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) may be reduced to the distance given in Table S-5 (see 7.8.d).

J. Employees standing on the ground may not contact the vehicle or mechanical equipment or any of its attachments, unless one of the following are met:
    1. The employee is using protective equipment rated for the voltage

    OR

    2. The equipment is located so that no uninsulated part its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in paragraph in Table S-5 (see 7.8.d)

K. If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding will not stand at the grounding location whenever there is a possibility of overhead line contact.

Portable Electric Equipment

A. All cord- and plug- connected electric equipment, flexible cord sets (extension cords), and portable electric equipment will be handled in a manner that will not cause damage.

B. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.

C. Flexible cords may not be fastened with staples or otherwise hung in such a fashion as could damage the outer jacket or insulation.

D. Portable cord- and plug- connected equipment and flexible cord sets (extension cords) shall be visually inspected before use and missing pins, or damage to outer jacket or insulation) and for evidence of possible internal damage (such as pinched or crushed outer jacket). However, cord- and plug- connected equipment and flexible cord sets (extension cords) which remain connected once they are put in place and are not exposed to damage need not be visually inspected until they are relocated.

E. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item will be removed from service, and no employee may use it until necessary repair and tests have been made to render the equipment safe.

F. Whenever an attachment plug is to be connected to a receptacle (including any on a cord set), the relationship of the plug and receptacle contacts will first be checked to ensure that they are of proper mating configurations.

G. A flexible cord used with grounding-type equipment will contain an equipment grounding conductor.

H. Attachment plugs and receptacles may not be connected or altered in a manner that would prevent proper continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, those devices may not be altered to allow the grounding pole of a plug to be inserted into slots intended for connection to the current carrying conductors.

I. Adapters that interrupt the continuity of the equipment grounding connection may not be used.

J. Portable electric equipment and flexible cords used in highly conductive work locations (such as those inundated with water or other conductive liquids), or in job locations where employees are likely to contact water or conductive liquids.

K. Employees' hands may not be wet when plugging and unplugging flexible cords and cords and plug-connected equipment if energized equipment is involved.

L. Energized plug and receptacle connections may be handled only with insulating protective equipment if the condition of the connection could provide a conducting path to the employee's hand (if, for example, a cord connector is wet from being immersed in water).

M. Locking-type connectors will be properly secured after connection.

Electric Power and Lighting Circuits

A. Load rated switches, circuit breakers, or other devices specifically designed as disconnecting means will be used for the routine opening, reversing, or closing of circuits under load conditions.

B. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections may not be used for such purposes, except In an emergency.

C. After a circuit is deenergized by a circuit protective device, the circuit may not be manually reenergized until it has been determined that the equipment and circuit can be safety energized. However, when it can be determined from the design of the circuit and the overcurrent devices involved that the automatic operating of a device was caused by an overload connected equipment is needed before the circuit is reenergized.

D. Repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited.

E. Overcurrent protection of circuits and conductors may not be modified, even on a temporary basis, beyond that allowed by the OSHA standard regulating the installation safety requirements for overcurrent protection (See 29 CFR 1910.304(f)).

Test Instruments and Equipment

A. Only qualified persons may perform testing work on electric circuits or equipment.

B. Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors will be visually inspected for external defects and damage before the equipment is used. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item will be removed from

service, and no employee may use the item until necessary repairs and tests to render the equipment safe have been made.

C. Test instruments and equipment and their accessories will be rated for the circuits and equipment to which they will be connected and will be designed for the environment in which they will be used.

Flammable or Ignitable Materials

A. In those situations where flammable materials are present only occasionally, electric equipment capable of igniting them will not be used, unless measures are taken to prevent hazardous conditions from developing.

B. Flammable materials include, but are not limited to:
   1. Flammable Gases
   2. Flammable Vapors
   3. Flammable Liquids
   4. Combustible Dust
   5. Ignitable Fibers or Filings

C. In those situations where flammable vapors, liquids or gases, or combustible dusts or fibers are (or may be) present on a regular basis, the electrical installation requirements contained in the OSHA standard regulating hazardous locations must be observed (See 29 CFR 1910.307).

Personal Protective Equipment (PPE) & Tools

A. This section outlines the minimum requirements for PPE selection, application, training and maintenance. The PPE selection process is based on potential and existing job hazards, risks, tasks, and procedures. Once a risk assessment has been performed and documented, the individual at risk shall take the necessary steps to minimize or eliminate the risks and shall select, apply, and utilize the necessary personal protective equipment for the task(s) to help prevent injury from shock, arc flash and other hazards.

B. Shock Protection– individuals performing the task shall conduct and document a Shock Hazard Risk Assessment and shall select and utilize the appropriate PPE and voltage-rated tools. Crossing the Restricted Approach Boundary requires PPE.

C. Effects of Electricity on the Human Body.
   1. The severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body. Variables including wet or broken skin and creating a pathway for electricity to flow through the chest can increase the severity of effects from a given current. It is important to be aware of how little current can lead to shock hazards to personnel.

2. Effects of Electric Current in the human body:
    a. At 1 milliampere, a faint tingle is perceptible.

    b. At 5 milliamperes, slight shock felt. May cause a strong involuntary reaction that can lead to other injuries.

    c. 6 - 30 milliamperes, painful shock and loss of muscular control. A person may not be able to voluntarily let go of the energized electrical conductor or circuit part.

    d. 50 - 150 milliamperes, extreme pain and respiratory arrest likely. Severe muscular contractions. Death is possible.

    e. 1 - 4.3 amperes, rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur. Death is likely.

    f. 10 amperes - cardiac arrest and severe burns occur. Death is probable.

    g. 15 amperes - the lowest overcurrent at which a typical fuse or circuit breaker opens a circuit.

3. Rubber Insulated Gloves **-** Rubber insulated gloves which are rated for the highest phase to phase or phase to ground (whichever requires higher voltage class glove) voltage shall be worn where there is danger of injury from electric shock (due to contact with energized electrical conductors or circuit parts). Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.

4. Hand and arm protection shall be worn where there is possible exposure to arc flash burn. Heavy-duty leather gloves shall be used for arc flash hazard protection. Where a shock hazard exists, rubber-insulated gloves (with the appropriate voltage rating /class) along with heavy-duty leather protectors are mandatory for working on energized equipment.

Arc Flash Risk Assessment

A. An arc flash risk assessment shall be performed and shall:
    1. Provide safety-related work practices.

    2. Define the arc flash boundary.

3. Specify the PPE to be used within the arc flash boundary.

4. Be updated when a major modification or renovation takes place. It shall be reviewed periodically, at intervals not to exceed 5 years, to account for changes in the electrical distribution system that could affect the results of the arc flash risk assessment.

5. Take into consideration the characteristics of the overcurrent protective device and its fault clearing time, including its condition of maintenance.

B. The results of the arc flash risk assessment shall be documented on the Energized Electrical Work Permit.

Arc Flash Boundary

A. The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm2.

B. The arc flash boundary shall be determined by use of the table in Appendix 9 or as defined by an Incident Energy Analysis.

Arc Flash PPE

A. One of the following methods shall be used for the selection of PPE. Either, but not both, methods shall be permitted to be used on the same piece of equipment.
   1. Incident Energy Analysis Method
   2. Arc Flash PPE Categories Method

B. Selection of arc-rated clothing and other PPE when the **Incident Energy Analysis Method** is used:

C. Incident energy exposures equal to 1.2 cal/cm2 up to 12 cal/cm2:
   1. Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy.

   2. Long-sleeve shirt and pants or coverall or arc flash suit.

   3. Arc-rated face shield and arc-rated balaclava or arc flash suit hood.

   4. Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) as needed.

   5. Heavy-duty leather gloves, arc-rated gloves, or rubber insulting gloves with leather protectors.

   6. Class E or G hard hat.

7. Safety glasses or safety goggles.

8. Hearing protection.

9. Leather footwear.

D. Incident energy exposures greater than 12 cal/cm2:
    1. Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy

    2. Long-sleeve shirt and pants or coverall or arc flash suit.

    3. Arc-rated arc flash suit hood.

    4. Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) as needed.

    5. Heavy-duty leather gloves, arc-rated gloves, or rubber insulting gloves with leather protectors.

    6. Class E or G hard hat.

    7. Safety glasses or safety goggles.

    8. Hearing protection.

    9. Leather footwear.

E. Arc Flash PPE Categories Method – If the equipment does not have an incident energy analysis label defining the Hazard Risk Category (HRC)/Arc Flash PPE Category, or list the calculated incident energy, the requirement for PPE and the appropriate arc flash PPE category required for the task may be determined from consulting Appendices 9 and 10 of this program along with a thorough risk assessment. If the equipment parameters defined in Appendices 9 and 10 do not match the equipment exactly, additional risk assessment must be conducted by a Qualified Person to determine the appropriate PPE category. Once the category is determined, personal protective equipment shall be

selected from the appropriate HRC/Arc Flash PPE Category listed below. (Also exhibited in Appendix 10).

Note: Appendix 10 and the Hazard Risk Categories/Arc Flash PPE Categories listed directly below only account for equipment where the maximum anticipated exposure level is 40 cal/cm2. Employees shall not work on energized equipment where the maximum anticipated exposure level exceeds 40 cal/cm2 (typically referred to as "Dangerous" by an Incident Energy Analysis/label).

F. Hazard Risk Category (HRC)/Arc Flash PPE Categories:
    1. HRC/Arc Flash PPE Category 1: Minimum Arc Rating of 4 cal/cm2 (16.75 J/cm2)
        a. Clothing - Arc-rated long-sleeve shirt and pants or arc-rated coverall, arc-rated face shield or arc flash suit hood, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

        b. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.

    2. HRC/Arc Flash PPE Category 2: Minimum Arc Rating of 8 cal/cm2 (33.5 J/cm2)
        a. Clothing – Arc-rated long-sleeve shirt and pants or arc-rated coverall, arc-rated face shield or arc flash suit hood, arc-rated balaclava, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

        b. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.

    3. HRC/Arc Flash PPE Category 3: Minimum Arc Rating of 25 cal/cm2 (104.7 J/cm2)
        a. Clothing – Arc-rated long-sleeve shirt, arc-rated pants, arc-rated coverall, arc-rated arc flash suit jacket, arc-rated flash suit pants, arc-rated arc flash suit hood, arc-rated gloves, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner

        b. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection, (ear canal inserts), leather footwear.

    4. HRC/Arc Flash PPE Category 4 Minimum Arc Rating of 40 cal/cm2 (167.5 J/cm2)
        a. Clothing – Arc-rated long-sleeve shirt, arc-rated pants, arc-rated coverall, arc-rated arc flash suit jacket, arc-rated lash suit pants, arc-rated arc flash suit hood, arc-rated gloves, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

        b. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), leather footwear.

G. Layering –Non-melting, flammable fiber garments shall be permitted to be used as underlayers in conjunction with arc-rated garments in a layered system. If non-melting, flammable fiber garments are used as underlayers, the system arc rating shall be sufficient to prevent breakopen of the innermost arc-rated layer at the expected arc exposure incident energy level to prevent ignition of flammable underlayers. Garments that are not arc-rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system. Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall NOT be permitted in clothing or in fabric under layers (underwear) next to the skin. Note – A typical layering system might include cotton underwear, a cotton shirt and trouser, and an arc-rated coverall. Specific tasks might call for additional arc-rated layers to achieve the require protection level.

H. Leather and/or Insulated Work Shoes/Boots – Foot protection of heavy-duty leather, work shoes/boots shall be worn for all tasks where incident energy exposure exceeds 4 cal/cm2. Toe guards and structural components shall be constructed of Structurally Engineered Moldable Composite (SEMC) Certified materials. Steel toe and component shoes are not allowed.

I. Insulating Blankets & Mats – Rubber insulating blankets and mats can be used to help protect the worker against shock hazards and to help limit accidental contact with energized electrical conductors, circuit parts or surfaces. Insulating blankets and mats shall be rated for the applicable phase-to-phase voltage. Blankets and mats shall be inspected before each use and shall be electrically tested before first use and at least once every twelve months after they are checked out for use. Complete records shall be kept of all such tests and date of issue. Insulating blankets and mats not checked out for use within twelve months shall be retested before being issued.

J. Arc Suppression Blankets – Arc suppression blankets can be used to help limit the exposure to a potential arc flash. Arc suppression blankets DO NOT provide for shock protection and are intended to help limit the exposure to arc flash. The blankets shall be rated for the potential energy to which they may be exposed.

K. Arc-Rated Jacket, Parka, or Rainwear – Arc-rated jackets, parkas, and/or rainwear appropriate for the potential hazard/risk category and incident energy level shall be provided to Qualified Persons performing work on or near energized electrical conductors or circuit parts where the worker may be exposed to rain or wet environments.

L. PPE Care and Inspection – PPE shall be maintained in a safe, clean and reliable condition. PPE shall be inspected before each use. Should the PPE be out of certified date range (i.e., rubber insulating glove testing requirements), worn out, damaged,

impaired or unsuitable for use or application, the worker has the responsibility to not use the PPE, tag the PPE with their name, a description of the problem and the date of the inspection and notify their supervisor. Work clothing or flash suits that are contaminated, or damaged to the extent their protective qualities are impaired, shall not be used.

1. Arc-rated apparel shall be stored in a manner that prevents physical damage; damage from moisture, dust, or other deteriorating agents; or contamination from flammable or combustible materials.

2. The garment manufacturer's instructions for care and maintenance of arc-rated apparel shall be followed.

Training

A. Appropriate training will be provided for those employees who face a risk of electric shock in the form of classroom and/or on the job instruction.

B. Each employee required to be trained will become familiar with the safe work practices required by this policy and those sections of the OSHA Electrical Standard that pertain to his/her respective job assignment(s).

C. Qualified persons (i.e., those persons permitted to work on or near exposed energized parts) will, at a minimum, be trained in the following:
   1. West Chester University's Electrical Safety Program and NFPA 70E initially upon assignment and periodically not to exceed a three-year period.

   2. The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment,

   3. The skills and techniques necessary to determine the nominal voltage of exposed parts, and

   4. The clearance distances specified in Table S (see 7.8.d) and the corresponding voltages to which the qualified person will be exposed.

B. The degree of training will be determined by the risk likely to be encountered\by the employee. The training given to "qualified persons" will be documented

Appendix 1 - Risk Assessment Process

The intent of this procedure is to perform a risk assessment, which includes a review of the electrical hazards, the associated foreseeable tasks, and the protective measures that are required in order to maintain a tolerable level of risk. A risk assessment should be performed before work is started.

Risk Assessment Steps

1. Identify the electrical hazards associated with the task and the electrical system, or electrical process involved (example: shock hazard risk; arc flash hazard risk).

2. Identify the electrical work to be performed within the electrical system or process.

3. Define the possible failure modes that result in exposure to electrical hazards and the potential resultant harm.

4. Assess the severity of the potential injury from the electrical hazards.

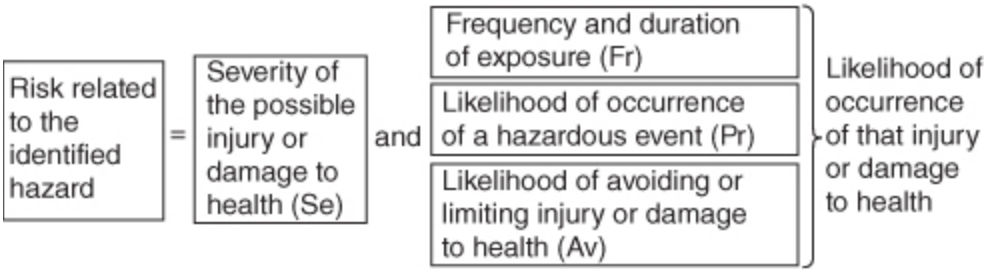
5. Determine the likelihood of the occurrence for each hazard.

6. Define the level of risk for the associated hazard.

7. If the level of risk is not acceptable, identify the additional measures or corrective actions to be taken.

Example: wear appropriate PPE and if the risk too great, do not perform the task.

The risk related to an identified hazard may be thought of as being composed of the severity of the injury and the likelihood of occurrence of that injury.



Risk Assessment Calculation

Following are two examples of methods that can be used to conduct electrical risk assessments. In the first, **The Risk Register Method**, the risk is derived using the risk parameters as shown in Figure 1. In the second, the risk is derived from using a **Risk Assessment Matrix** as shown in Figure 2.

Risk Register Method

A. Severity of the Possible Injury or Damage to Health (Se) – Severity of injuries or damage to health can be estimated by taking into account reversible injuries, irreversible injuries, and death. Typically, the types of hazards to be considered include, but are not limited to, shock and electrocution, burns, and impact. Choose the appropriate Severity value from Table 1 below. Add value to the Risk Register (Table 5)

Table 1

Severity of Injury of Damage to Health	**Se Value**
Irreversible – trauma, death.	8
Permanent – skeletal damage, blindness, hearing loss, third degree burns.	6
Reversible – minor impact, hearing damage, second degree burns.	3
Reversible – minor laceration, bruises, first degree burns.	1

B. Frequency and Duration of Exposure (Fr) - The following aspects should be considered to determine the level of exposure: a. Need for access to the hazard zone based on all modes of use; for example, normal operation and maintenance.
    1. Nature of access, for example, examination, repair, and troubleshooting.

Choose the appropriate Frequency value from Table 2 below. Add value to the Risk Register (Table 5)

Table 2

Frequency of Exposure	**Fr Value (for Duration > 10 min)**
< 1 per hour	5
> 1 per hour to < 1 per day	5
> 1 per day to < 1 every 2 weeks	4
> 1 every 2 weeks to < 1 per year	3
> 1 per year	2

C. Likelihood of Occurrence of a Hazardous Event (Pr) – The occurrence of a hazardous event influences the likelihood of the occurrence of injury or damage to health. The possibility of the hazardous occurring should describe the likelihood of the event materializing during the use or foreseeable misuse, or both, of the electrical system or process. Subjectivity may have a substantial impact on the result of the risk assessment. The use of subjective information should be minimized as far as reasonably practicable.
    1. The likelihood of occurrence of the hazardous event should be estimated independently of other related parameters (Fr and Av) and will typically be based on the results of the completed study of the arc flash potential. The worst-case scenario should be used for this parameter to ensure that short-circuit interruption device(s) have, where practicable, been properly selected and installed and will provide adequate protection.

Elements of the electrical system that are intended to ensure an intrinsically safe design shall be taken into consideration in the determination of the likelihood of the hazardous event(s). These can include, but are not limited to, the mechanical structure, electrical devices, and electronic controls integral to the system, the process, or both at the time of the analysis. Types of components that could contribute to an inherently safe design include, but are not limited to, current-limiting devices and ground-fault circuit interrupters.

2. This parameter can be estimated by considering the following factors:
    a. The predictability of the performance of component parts of the electrical system relevant to the hazard in different modes of use (e.g., normal operation, maintenance, fault finding). At this point in the risk assessment process, the protective effect of any personal protective equipment (PPE) and other protective measures should not be considered. This is necessary in order to estimate the amount of risk that will be present if the PPE and other protective measures are not in place at the time of the exposure. In general terms, it must be considered whether the electrical system being assessed has the propensity to act in an unexpected manner. The electrical system performance will vary from very predictable to not predictable. Unexpected events cannot be discounted until it can be clearly demonstrated that the electrical system will perform as expected.

3. The specified or foreseeable characteristics of human behavior with regard to interaction with the component parts for the machine relevant to the hazard, which can be characterized by one or both of the following:
    a. Stress (e.g., due to time constraints, work task, perceived damage limitation).

    b. Lack of awareness of information relevant to the hazard.

Human behavior will be influenced by factors such as skills, training, experience, and complexity of the machine or the process.

These attributes are not usually directly under the influence of the electrical system designer, but a task analysis will reveal activities in which total awareness of all issues, including unexpected outcomes, cannot be reasonably assumed. “Very high” likelihood of occurrence of a hazardous event should be selected to reflect normal workplace constraints and worst-case considerations. Positive reasons (e.g., well-defined application and a high level of user competence) are required for any lower values to be used.

Any required or assumed skills, knowledge, and so forth, should be stated in the information for use.

Select the appropriate value for Likelihood of Occurrence of Hazardous Event (Pr) from Table 3 below. Add value to the Risk Register (Table 5).

Table 3

Likelihood of a Hazardous Event	**Pr Value**
Very high	5
Likely	4
Possible	3
Rare	2
Negligible	1

4. Listed below are examples of general questions to consider in determining the likelihood of an event (risk):
    a. Has the equipment been installed in accordance with *NFPA 70®, National Electrical Code® (NEC®)*?

    b. Has the equipment been maintained and tested in accordance with the manufacturer's instructions?

    c. How old is the equipment?

    d. Is there any visual indication of overheating?

    e. Is any component, device, or equipment loose or damaged?

5. The following are enclosure questions:
    a. Do all enclosure doors operate and latch properly?

    b. Does the enclosure have all of its bolts and screws installed?

    c. Does the equipment or enclosure have ventilation openings?

    d. Is the enclosure arc rated?

    e. Are there openings in the enclosure that rodents or other vermin could enter?

    f. Is there an indication of moisture in the equipment?

    g. Has the enclosure been examined for dust, dirt, soot, or grease?

h. Is there any indication of overheating of the bus work, etc., in the enclosure, such as discoloration?

6. The following are circuit breaker (CB) condition questions:
    a. Has the CB periodically been operated in accordance with the manufacturer's instructions?

    b. Has the CB been applied within its marked rating?

    c. Has the right type of CB been used?

    d. Have the proper conductor types and sizes been used to connect to the CB?

    e. Has the CB been checked for burn marks?

    f. Have the CB surfaces been examined for dust, dirt, soot, grease, or moisture? If any was found, have the CB surfaces been appropriately cleaned?

    g. Has the CB been examined for cracks?

    h. Have all electrical connections to the CB been checked to be certain that they are clean and secure?

    i. Is there any indication of discoloration of the CB's molded case, discoloration or flaking of external metal parts, or melting or blistering of adjacent wire insulation?

    j. Is there any evidence of overheating or melting of the arc chute vent or area surrounding the vents?

    k. Is there evidence of overheating or case blistering?

    l. If the CB has interchangeable trip units, have the trip units been visually checked for overheating or looseness?

    m. Have mechanical operation tests been performed on the CB and proper contact operation verified?

    n. Have insulation resistance and/or individual pole resistance (millivolt drop) tests been performed on the CB?

o. Have inverse-time and/or instantaneous overcurrent trip tests been conducted on the CB?

p. What is the ampere rating of the CB involved?

D. Likelihood of Avoiding or Limiting Injury or Damage to Health (Av) – This parameter can be estimated by considering aspects of the electrical system design and its intended application that can help to avoid or limit the injury or damage to health from a hazard, including the following examples:

1. Sudden or gradual appearance of the hazardous event; for example, an explosion caused by high fault values under short-circuit conditions.

2. Spatial possibility to withdraw from the hazard.

3. Nature of the component or system; for example, the use of touch-safe components, which reduce the likelihood of contact with energized parts. Working in close proximity to high voltage can increase the likelihood of personnel being exposed to hazards due to approach to live parts.

4. Likelihood of recognition of hazard; for example, as an electrical hazard, a copper bar does not change it appearance, whether it is under voltage or not. To recognize the presence of the hazard, an instrument is needed to establish whether or not electrical equipment is energized; thus, both inadvertent and intentional contact need to be considered.

Select the appropriate value for Likelihood of Avoiding or Limiting Injury or Damage to Health (Av) from the Table 4. Add the value to the Risk Register (Table 5).

Table 4

Likelihood of Avoiding or Limiting Injury or Damage to Health	**Av Value**
Impossible	5
Rare	3
Probable	1

Risk Register – Enter Values from Tables 1, 2, 3 & 4.

Table 5

Scenario No.	Hazard	Severity	Probability of Occurrence of Harm Po = (Fr+Pr+Av)	Risk Score (R)

Se	Fr	Pr	Av	Total	Se x Po

Scenario No.	Hazard	Severity	Probability of Occurrence of Harm Po = (Fr+Pr+Av)				Risk Score (R)
		SE	Fr	Pr	Av	Total	Se x Pr

A Risk Score (R) Higher Than 10 Requires Consideration of Additional Safety Controls

A. Risk Matrix Method
    1. A risk assessment matrix is a simple table that groups risk based on severity and likelihood. It can be used to assess the need for remedial action, such as the use of PPE for a given task, and to prioritize safety issues.

B. The following title categories are used to define the risk:
    1. Likelihood of Occurrence:
        a. Definite – Almost certain of happening.

        b. Likely – Can happen at any time.

        c. Occasional – Occurs sporadically, from time to time.

        d. Seldom – Remote possibility; could happen sometime; most likely will not happen.

        e. Unlikely – Rare and exceptional for all practical purposes; can assume it will not happen.

    2. Severity of Injury:
        a. Catastrophic – Death or permanent total disability (PTD).

        b. Critical – Permanent partial disability (PPD) or temporary total disability (TTD) 3-months or longer.

c. Medium – Medical treatment and lost work injury (LWI).

d. Minor – Minor medical treatment possible.

e. Slight – First aid or minor treatment.

Figure 2 Risk Assessment Matrix

Likelihood of occurrence in period	**Slight**	**Minor**	**Medium**	**Critical**	**Catastrophic**
Cal/cm2	< 1.2	> 1.2 to < 8		> 8 to < 40	> 40
Unlikely	L	L	L	M	M
Seldom	L	L	M	M	H
Occasional	L	M	M	H	E
Likely	M	M	H	E	E
Definite	M	H	E	E	E

C. Interpretation of Risk Assessment Matrix:

1. **Extreme (E) - Intolerable risk:** Do not proceed. Immediately introduce further controls. Detailed action plan required. Color code red.

2. **High (H) - Unsupportable risk:** Review and introduce additional controls. Requires senior management attention. Color code orange.

3. **Moderate (M) - Tolerable risk:** Incorporates some level of risk that is unlikely to occur. Specific management responsibility. Consider additional controls. Take remedial action at appropriate time. Color code yellow.

4. **Low (L) - Supportable risk:** Monitor and maintain controls in place. Manage by routine. Procedures. Little or no impact. Color code green.

Protective Measures

A. The appropriate protective measures include the following:

1. Elimination

2. Substitution

3. Engineering controls

4. Awareness

5. Administrative controls (Procedures)

6. Training

7. Personal Protective Equipment (PPE)

8. Mitigation

B. Examples:
    1. Elimination: Eliminate the hazard. Turn the equipment off and verify a safe work condition.

    2. Substitution: Think through the entire procedure and substitute methods and procedures that constitute lower risk.

    3. Engineering Controls: Engineering controls can have a substantial impact on risk. They should, where practicable, be considered and analyzed. Typically, engineering controls take the form of barriers and other safeguarding devices such as GFCI protection, zone selective interlocking, differential relaying, energy reducing maintenance switches, high resistive grounding and current limiting devices.

    4. Awareness: Awareness means can be used to complement the effects of engineering controls with regard to risk reduction. They should be chosen based on the design configuration for each specific application and their potential effectiveness during foreseen interaction. Each design and configuration can require unique awareness devices in order to have the desired impact on risk. Typically, awareness means take the form of signs and visual and audible alarms.

    5. Administrative Controls (Procedures): Procedures and instructions that are required for individuals to safely interact with the electrical system should be identified. The procedures and instruction should include descriptions of the hazards, the possible hazardous events, hazardous situations, and the protective measures that need to be implemented. Procedures and instructions should also be used to communicate foreseeable misuse of the system that could contribute to an increased level of risk. Typically, formal procedures are provided in written form; however, in some cases, verbal instruction can be provided. Care should be taken in the latter case to ensure that the verbal instructions will have the desired impact on risk.

6. Training: Training, with regard to the proper interaction and for foreseeable inappropriate interaction with the electrical system, must be completed. The intent of the training is to ensure that all affected personnel are able to understand when and how hazardous situations can arise and how to best reduce the risk associated with those situations. Typically, training for individuals interacting with electrical systems will include technical information regarding hazards, hazardous situations, or both as well as information related to potential failure modes that could affect risk. This type of training generally will be provided by a trainer who has an in-depth understanding of electrical system design, as well as experience in the field of adult education. Less technical training content could be appropriate in situations in which only awareness of electrical hazards is needed to ensure that unqualified personnel do not interact with the electrical system.

7. Personal Protective Equipment (PPE): The electrical system must be analyzed in order to determine the appropriate PPE. Once the appropriate PPE has been determined, personnel must maintain and use it as required in order to ensure that residual risk remains at the desired level. PPE is the last line of defense.

8. Mitigation – Emergency procedures. Identify who is going to provide assistance and summon help if needed.

Appendix 2 – Shock Protection Approach Boundaries (AC/DC)

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**
	Exposed Movable Conductor	**Exposed Fixed Circuit Part**	Includes Inadvertent Movement Adder.
Less than 50	Not specified	Not specified	Not specified
50 to 150	10 ft. 0 in.	3 ft. 6 in.	Avoid contact
151 to 750	10 ft. 0 in.	3 ft. 6 in.	1 ft. 0 in.
751 to 15 kV	10 ft. 0 in.	5 ft. 0 in.	2 ft. 2 in.
15.1 kV to 45 kV	10 ft. 0 in.	8 ft. 0 in.	2 ft. 9 in.

Appendix 3 – Energized Electrical Work Permit

Work Request
(To be completed by the person requesting the review)

Work site location: (building & room number)	**Work Request/Project no.:**
Start date/time:	**End date/time:**
Description of the work to be performed:	
Equipment requested to be shut down:	
Until work is complete Temporarily, while barriers are being placed? ☐ Yes ☐ No	
Requested by:	**Signature:**
Title:	**Date:**

Hazard Analysis
(To be completed by the Electrically Qualified Persons doing the work)

Shock Analysis/Approach Boundaries:

Limited approach boundary- _____ft. _____in.

Restricted approach boundary- _____ft. _____in.

Work will be conducted within this boundary (NFPA 70E 130.4)

Results of the arc flash hazard analysis (Determined from table in Appendix 9) **____ft. _____in.**
NFPA 70E 130.7 (C)(15)(A) &(B)

Calculation results: ____ft. _____in.

PPE category for the task: ☐ 1 ☐ 2 ☐ 3 ☐ 4 (from Table 130.7(C)(15)(A) & (B))

ATPV rating (in cal/cm2) for arc-rated clothing:

☐ N/A ☐ 4 (Cat 1) ☐ 8 (Cat 2) ☐ 25 (Cat 3) ☐ 40 (Cat 4)

Equipment Being Used
(Check all that apply)

- ☐ Voltage-rated tools
- ☐ Voltage-rated gloves
- ☐ Safety glasses
- ☐ Hearing protection
- ☐ Leather gloves
- ☐ Leather work shoes
- ☐ Hard hat
- ☐ Hard hat liner (arc-rated)
- ☐ Short sleeve shirt (natural fiber)
- ☐ Long sleeve shirt (natural fiber)
- ☐ Long pants (natural fiber)
- ☐ Long sleeve shirt (arc-rated)
- ☐ Long pants (arc rated)
- ☐ Coveralls (arc-rated)
- ☐ Jacket/rainwear (arc-rated)
- ☐ Flash suit jacket (arc-rated)
- ☐ Flash suit pants (arc-rated)
- ☐ Face shield (arc-rated)
- ☐ Flash suit hood (arc-rated)
- ☐ 25-Cal Suit
- ☐ 40-Cal Suit

Check all means employed to restrict the access of Unqualified Persons from the work area:

☐ Signs/tags ☐ Barricades ☐ Attendants

Has a documented job briefing with detailed procedures been conducted?

☐ Yes, see attached ☐ No

Do you agree that the work can be done safely? ☐ Yes ☐ No **Date:**

Electrically Qualified Person(s) Name and Signature:

Justification for the live work request:

☐ **Shut down creates an increased/additional hazard (specify below):**

☐ **Shut down is infeasible due to design or operational limitations (specify below):**

The next available date for shutdown is:

Request for energized electrical work: **Date:**

Electrically Qualified Person Name and Signature:

Proposed Energized Electrical Work Review

Proposed energized electrical work has been reviewed by:	**Supervisor:**	**Date:**
	Manager of Trades or Facilities:	**Date:**
	EHS:	**Date:**

Appendix 4 – Job Briefing Checklist

ELECTRICAL SAFETY JOB PLANNING & BRIEFING CHECKLIST

Identify	
1. The hazards	2. Number of people needed to do the job
3. The voltage levels involved	4. The shock protection boundaries
5. Skills required	6. The available incident energy
7. Any "foreign" (secondary source) voltage source	8. Potential for arc flash (Flash-hazard analysis)
9. Any unusual work conditions	10. The flash protection boundaries
Ask	
1. Can the equipment be de-energized?	2. Is a standby person required?
3. Can the circuits to be worked on be back fed?	
Check	
1. Job plans	2. Safety procedures
3. Single-line diagrams and vendor prints	4. Vendor information
5. Status board	6. That individuals are familiar with the facility
7. Facility and vendor resource information is up to date	
Know	
1. What the job is	2. Who is in charge?
3. Who else needs to know?	
Think	
1. Plan for the unexpected	2. Install and remove grounds
3. Lock-Tag-Test-Try	4. Install barriers and barricades
5. Test for voltage – FIRST	6. Using the appropriate equipment and PPE
Prepare for an emergency	
1. Is the standby person CPR trained?	2. What is the exact work location?
3. Where is the emergency equipment stagged?	4. Is the emergency shut-off easily accessible?
5. Where is the nearest telephone?	6. Where is the fire extinguisher?
7. Where is the fire alarm?	8. Are communications available?
9. Is confined space rescue available?	

ELECTRICAL SAFETY JOB PLANNING & BRIEFING CHECKLIST (Page 2)

COMPLETED BY: _____ DATE: _____

TASK: _____

LOCATION: _____

ATTENDEES

_____

_____

_____

_____

_____

_____

_____

_____

_____

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_____

Notes:

Appendix 5 – How to read Incident Energy Labels/Arc Flash Labels

All labels are divided into 2 parts: Arc Flash and Shock Protection Information

WARNING

Arc Flash and Shock Risk
Appropriate PPE Required

FLASH PROTECTION		SHOCK PROTECTION
2.0 cal/cm^2 @ 36 "	Flash Protection Boundary: 62 " Refer to NFPA 70E Standards for PPE	13800 VAC Shock Risk when Exposed Limited Approach: 60 " Restricted Approach: 26 " Class 00 or 0 Gloves, insulated Tools Required

Equipment: **15KV DUPLEX SWITCH** Proj No: G140005-00
Fed From: **SUBSTATION 13-25** Date: 02/05/18
Fault Current (KA): **5.28 kA** Completed by:

A. Shock Protection
   1. Nominal system voltage when “exposed energized parts” are present is listed.

   2. Limited Approach Boundary indicates the closest distance Unqualified Persons may approach.

   3. Restricted Approach Boundary indicates when rubber gloves must be worn.

B. Flash Protection
   1. The Arc Flash PPE requirements are defined either by providing the Arc Flash PPE/HRC category/OR the incident energy level. The label should not contain both the incident energy value AND PPE category because it can lead to confusion.

   2. The incident energy is the amount of energy available at the working distance. Wear arc rated PPE rated at minimum with this calorie rating when within the Flash Protection Boundary.

   3. The Flash Protection Boundary is the distance from the source that a person could receive a second degree burn if a flash occurred. All parts of your body within this boundary must be protected from a flash.

Appendix 6 – Additional Safe Work Practice Descriptions

A. **Positively ensure the correct circuit is identified before lockout and tagout:** Electrical workers are routinely hurt because the breaker locked out was the wrong one. Before you lock out a circuit breaker or power disconnect switch, check that you are locking out the correct breaker --- the one that controls the equipment on which you will be working. Breaker off, the equipment stops. Breaker on, the equipment runs. Please verify this occurs before locking out.

B. **Whenever possible de-energize the equipment before testing:** Conduct tests with the electrical equipment de-energized; or if there is no other way to perform the test, follow the procedure for working on energized equipment. (Appendix 3)

C. **The employee in charge must conduct a job briefing before all energized electrical work:** Before starting any diagnostics & testing energized electrical work, the Qualified Person must complete a Job Planning Checklist and conduct a job briefing with the employee(s) performing the work. (Appendix 4)

D. **Identify hazards and anticipate problems:** Think through what might go wrong and the consequences of that action. Do not hesitate to discuss any situation or question with your supervisor and coworkers.

E. **Resist "hurry-up" pressure:** Program pressures should not cause you to bypass thoughtful consideration and planned procedures.

F. **Don't hesitate to use the Stop Work Policy:** Do not hesitate to use it if you see a fellow worker performing unsafe acts.

G. **Always consider electrical equipment energized unless positively proven otherwise:** When working on electrical equipment, treat the equipment as live until it is tested (verified deenergized), locked, tagged, shorted, and/or grounded, as appropriate.

H. **Use suitably rated electrical devices only as intended:** Electrical devices shall be fully rated for the system to be tested and must not be modified beyond the intent of their design.

I. **Remove or cover all jewelry before performing energized electrical work:** This includes rings, watches, or metal pendants, keyrings and chains that could inadvertently fall into the work. Metal-framed glasses must be restrained when working around electrical equipment.

J. **Know how to shut down equipment in an emergency:** Know the location, and operation of, emergency disconnects for all sources of power to equipment before beginning energized work.

K. **Know emergency procedures:** All persons working in areas of high hazard (with high-voltage power supplies, capacitor banks, etc.) must be trained in emergency response procedures, which includes how to immediately summon help and provide aid to those in need. Verify communication means to summon outside help. Qualified Persons working on or observing work on energized transmission and distribution conductors and circuit parts shall maintain cardiopulmonary resuscitation (CPR) and First Aid certification.

L. **Design for safety:** Consider safety to be an integral part of the design process. Protective devices, warning signs, and administrative procedures are supplements to good design—not a substitute for it. Engineering controls are always preferable to administrative controls. Completed designs should include provisions for safe maintenance.

M. **Reset circuit breakers only after the trip problem has been defined:** One reset will be allowed for circuits 100 amps and below. If the problem still exists, the problem must be repaired before the circuit can be reset. When a circuit breaker or other over current device trips, it is usually due to an overload or fault condition on the line. Repeated attempts to re-energize the breaker under these conditions may cause the breaker to explode. Do not attempt to reset a circuit breaker unless the problem has first been identified and corrected or isolated.

N. **Maintain the protection of covers, barriers and shielding:** When you remove a panel or cover for access (a barrier), replace it with a temporary barrier to restore at least some of your protection. This could be a rubber sheet or blanket, placed over the portions of the equipment under test to which you do not need access. Provide a means to barricade and mark the Arc Flash Protection Boundary to limit access area to Qualified Personnel only. This should be accomplished by using Energized Area Signs and/or Caution Energized Area Tape.

O. **Never drill into a wall or floor slab without checking the area for concealed utilities or hidden hazards:** Before drilling into a wall or floor, wear suitable PPE for the working conditions (dirt, slurry, debris) in case of an unknown electrical hazard. At a minimum, this will include safety glasses, hard hats, all leather shoes, and fully rated gloves.

P. **Never modify or penetrate premises wiring conduit or enclosed wireways**: Only Qualified Personnel are allowed to work on premise wiring, conduits or enclosed wiring.

Q. **Utilize PPE as last line of defense**: Know both shock protection and arc flash boundaries. Determine what voltage you are working on. Use the appropriated PPE and insulated tools.

R. **Turn off cell phones while working around energized equipment**: Similar to texting and driving don’t mix; cell phones can’t be a distraction while working around energized equipment.

Appendix 7 – Electrical Safety Audit Checklist

Location: _____ Completed by: _____

Safety audit requirement	Yes	No
One-line diagram exists		
One-line diagram is legible		
One-line diagram is correct		
All persons who operate the power system have easy access to the current one-line diagrams		
Equipment is labeled correctly, legibly, and in accordance with the one-line diagram		
Persons who operate/maintain electrical equipment are trained for the voltage-class equipment they operate/maintain		
Working with de-energized equipment procedures exist and are followed		
Working with live equipment procedures exist and are followed		
Equipment is grounded properly		
Safety grounding equipment, PPE, and working tools (i.e., hot sticks, voltage testers) have been calibrated and tested		
Ground system is tested periodically		
Electrical equipment is free from corrosion		
Proper maintenance practices are followed, especially for fault-protection equipment		
Recent (less than five years old) coordination study exists, and overcurrent devices are calibrated to the setting recommended		
Up-to-date arc-flash hazard assessment is complete, equipment is labeled, and employees are aware of the hazard		
Power system is resistance grounded		
Written switching orders are reviewed and used		

Appendix 8 – Arc Flash Hazard Identification for AC and DC Systems

Task	Equipment Condition*	Arc Flash PPE Required?
Reading a panel meter while operating a meter switch	Any	No
Normal operation of a circuit breaker (CB), switch, contactor, or starter	**All of the following:** 1. The equipment is properly installed 2. The equipment is properly maintained 3. All equipment doors are closed and secured 4. All equipment covers are in place and secured 5. There is no evidence of impending failure	No
	One or more of the following: 1. The equipment is not properly installed 2. The equipment is not properly maintained Equipment doors are open or not secured 3. Equipment covers are off or not secured 4. There is evidence of impending failure	Yes
For ac systems: Work on energized electrical conductors and circuit parts, including voltage testing	Any	Yes
For dc systems: Work on energized electrical conductors and circuit parts of series-connected battery cells, including voltage testing	Any	Yes
Voltage testing on individual battery cells or individual multi-cell units	**All of the following:** 1. The equipment is properly installed 2. The equipment is properly maintained 3. Covers for all other equipment are in place and secured 4. There is no evidence of impending failure	No
	One or more of the following: 1. The equipment is not properly installed 2. The equipment is not properly maintained Equipment doors are open or not secured 3. Equipment covers are off or not secured 4. There is evidence of impending failure	Yes
Removal or installation of CBs or switches	Any	Yes

Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare energized electrical conductors and circuit parts	**All of the following:** 1. The equipment is properly installed 2. The equipment is properly maintained 3. There is no evidence of impending failure	No
	Any of the following: 1. The equipment is not properly installed 2. The equipment is not properly maintained 3. There is evidence of impending failure	Yes
Removal of bolted covers (to expose bare energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers	Any	Yes
Removal of battery intercell connector covers	**All of the following:** 1. The equipment is properly installed 2. The equipment is properly maintained 3. Covers for all other equipment are in place and secured 4. There is no evidence of impending failure	No
	One or more of the following: 1. The equipment is not properly installed 2. The equipment is not properly maintained Equipment doors are open or not secured 3. Equipment covers are off or not secured 4. There is evidence of impending failure	Yes
Opening hinged door(s) or cover(s) (to expose bare energized electrical conductors and circuit parts)	Any	Yes
Perform infrared thermography and other noncontact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers	Any	No
Application of temporary protective grounding equipment after voltage test	Any	Yes
Work on control circuits with exposed energized electrical conductors and circuit parts, 120 volts or below without any other exposed energized equipment over 120 volts including opening of hinged covers to gain access	Any	No
Work on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts.	Any	Yes

Insertion or removal of individual starter buckets from motor control center (MCC)	Any	Yes
Insertion or removal (racking) of CBs or starters from cubicles, doors open or closed	Any	Yes
Insertion or removal of plug-in devices into or from busways	Any	Yes
Insulated cable examination with no manipulation of cable	Any	No
Insulated cable examination with manipulation of cable	Any	Yes
Work on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center	Any	Yes
Insertion and removal of revenue meters (kW-hour, at primary voltage and current)	Any	Yes
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an enclosure	Any	Yes
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack	Any	No
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack	Any	No
For dc systems, work on exposed energized electrical conductors and circuit parts or utilization equipment directly supplied by a dc source	Any	Yes
Arc-resistant switchgear Type 1 or 2 (for clearing times of <0.5 sec with a prospective fault current not to exceed the arc-resistant rating of the equipment) and metal enclosed interrupter switchgear, fused or unfused of arc resistant type construction, tested in accordance with IEEE C37.20.7: A. Insertion or removal (racking) of CBs from cubicles B. Insertion or removal (racking) of ground and test device C. Insertion or removal (racking) of voltage transformers on or off the bus	**All of the following:** 1. The equipment is properly installed 2. The equipment is properly maintained 3. All equipment doors are closed and secured 4. All equipment covers are in place and secured 5. There is no evidence of impending failure	No
	One or more of the following: 1. The equipment is not properly installed 2. The equipment is not properly maintained 3. Equipment doors are open or not secured 4. Equipment covers are off or not secured 5. There is evidence of impending failure	Yes

Opening voltage transformer or control power transformer compartments	Any	Yes
Outdoor disconnect switch operation (hook stick operated) at 1 kV through 15 kV	Any	Yes
Outdoor disconnect switch operation (gang-operated, from grade) at 1 kV through 15 kV	Any	Yes

Note: Hazard identification is one component of risk assessment. Risk assessment involves a determination of the likelihood of occurrence of an incident, resulting from a hazard that could cause injury or damage to health. The assessment of the likelihood of occurrence contained in this table does not cover every possible condition or situation. Where this table indicates that arc flash PPE is not required, an arc flash is not likely to occur.
*The phrase *properly installed*, as used in this table, means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer's recommendations. The phrase *properly maintained*, as used in this table, means that the equipment has been maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards. The phrase *evidence of impending failure*, as used in this table, means that there is evidence of arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or other damage.

Appendix 9 – Arc Flash Hazard PPE Requirements for AC and DC Systems

Equipment – AC Systems	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 Volts and below Parameters: Maximum of 25 kA short-circuit current available; maximum 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	1	19 inches
Panelboards or other equipment rated > 240 volts and up to 600 volts Parameters: Maximum of 25 kA short-circuit current available; maximum 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	3 ft.
600 V class motor control centers (MCCs) Parameters: Maximum of 65 kA short-circuit current available; maximum 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	5 ft.
600 V class motor control centers (MCCs) Parameters: Maximum of 42 kA short-circuit current available; maximum 0.33 sec (20 cycles) fault clearing time; working distance 18 inches	4	14 ft.
600 V class switchgear (with power circuit breakers or fused switches) and **600 V class switchboards** Parameters: Maximum of 35 kA short-circuit current available; maximum 0.5 sec (30 cycles) fault clearing time; working distance 18 inches	4	20 ft.
Other 600 V class (277 V through 600 V, nominal) equipment Parameters: Maximum of 65 kA short-circuit current available; maximum 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	5 ft.
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4	40 ft.
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4	40 ft.
Arc resistant switchgear Type 1 or 2 (for clearing times of <0.5 sec (30 cycles) with a perspective fault current not to exceed the arc-resistant rating of the equipment), and metal enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, tested in accordance with IEEE C37.20.7. 1 kV through 15 kV	N/A (doors closed)	N/A (doors closed)
Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4 (doors open)	40 ft.
Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA short-circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4	40 ft.

Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below category 1.

Equipment – DC Systems	Arc Flash PPE Category	Arc Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources 100 V > Voltage < 250 V Parameters: Voltage: 250 V Maximum arc duration and working distance 2 sec @18 inches		
Short circuit current < 4 kA	1	3 ft.
4 kA< short-circuit current < 7 kA	2	4 ft.
7 kA< short-circuit current < 15 kA	3	6 ft.
Storage batteries, dc switchboards, and other dc supply sources 250 V < Voltage < 600 V Parameters: Voltage: 600 V Maximum arc duration and working distance 2 sec @18 inches		
Short-circuit current 1.5 kA	1	3 ft.
1.5 kA < short-circuit current < 3 kA	2	4 ft.
3 kA < short-circuit current < 7 kA	3	6 ft.
7 kA < short-circuit current < 15 kA	4	8 ft.

Note: A conservative value for the DC short circuit current is calculated by 10 times the 1-minute ampere rating of the battery. A more accurate value for the short circuit current can be obtained from the battery manufacturer.

Appendix 10 – HRC/Arc Flash PPE Requirements Categories

HRC/Arc Flash PPE Category 1: Minimum Arc Rating of 4 cal/cm2

A. Clothing - Arc-rated long-sleeve shirt and pants or arc-rated coverall, arc-rated face shield or arc flash suit hood, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

B. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.

HRC/Arc Flash PPE Category 2: Minimum Arc Rating of 8 cal/cm2

A. Clothing – Arc-rated long-sleeve shirt and pants or arc-rated coverall, arc-rated face shield or arc flash suit hood, arc-rated balaclava, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

B. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.

HRC/Arc Flash PPE Category 3: Minimum Arc Rating of 25 cal/cm2

A. Clothing – Arc-rated long-sleeve shirt, arc-rated pants, arc-rated coverall, arc-rated arc flash suit jacket, arc-rated flash suit pants, arc-rated arc flash suit hood, arc-rated gloves, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

B. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection, (ear canal inserts), leather footwear.

HRC/Arc Flash PPE Category 4: Minimum Arc Rating of 40 cal/cm2

A. Clothing – Arc-rated long-sleeve shirt, arc-rated pants, arc-rated coverall, arc-rated arc flash suit jacket, arc-rated lash suit pants, arc-rated arc flash suit hood, arc-rated gloves, arc-rated jacket, parka, rainwear, or arc-rated hard hat liner.

B. PPE – Class G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), leather footwear.