University of Pennsylvania

Electrical Safety Program

Environmental Health & Radiation Safety
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Contents

1. PURPOSE & CORE PRINCIPLES

Electricity has long been recognized as a serious workplace hazard, exposing employees to such dangers as electric shock, electrocution, fires and explosions. The Electrical Safety Program is designed to prevent electrically related injuries and property damage. This program also provides for proper training of University of Pennsylvania (Penn) employees to ensure they have the requisite knowledge and understanding of electrical work practices and procedures. Only employees qualified in this program may conduct adjustment, repair or replacement of electrical components or equipment

All electrical facilities shall be installed and maintained in a safe manner. All work involving electrical energy shall be performed in a safe manner. The primary safe work practice is to establish an electrically safe work condition (performing work de-energized which includes lockout/tagout).

A basic rule that should be derived from this statement is that work on exposed energized conductors or parts should be prohibited, except under justified, controlled, and approved circumstances.

A) The **Core Principles** for Penn's Electrical Safety Program include, but are not limited to, the following:

- **Plan every job**. Decide on your approach and step-by-step procedures. Discuss hazards and procedures in a job briefing with your supervisor and other workers before starting a job.
- **De-energize the equipment to be worked on**. Whenever possible, energized conductors and circuit parts to which you might be exposed should be put into an **electrically safe work condition.**
- **Conduct a Risk Assessment by identifying and minimizing the electrical hazard**. Identify steps that could create electric shock or arc flash hazards. Deenergize the equipment or insulate or isolate exposed energized conductors or circuit parts so you cannot contact them.
- **Anticipate the unexpected**. Protect yourself from shock, burn, blast, and other hazards due to the working environment.
- **Inspect and evaluate the electrical equipment**. Verify the voltage you are working on by reading the nameplate on equipment.
- **Use the right tools for the job**. Make sure you have the proper personal protective equipment (PPE) and voltage-rated gloves and tools for the job.
- **Assess people's abilitie**s. Make sure you and everyone working with you is a Qualified Person with appropriate training for the job.
- **Audit these principles**. Follow these principles on each and every job and review them periodically.

B) Energized Electrical Work Policy

It is Penn's policy to perform electrical work on de-energized systems (locked and tagged out).

There may be rare circumstances that necessitate work on energized systems. This may be the case if deenergizing 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.

Justification for energized work must be provided including the following:

- The appropriate job hazard/risk analysis
- Workers and supervisory staff acknowledge they are "qualified" for the task(s)
- The work can be conducted in a safe manner
- Proper safety planning and preparation occurs
- Proper personal protective equipment (PPE) is utilized

Applicable documents may include, but not be limited to PPE Checklist, Job Briefing and Energized Electrical Work Permit.

2. SCOPE

This program applies to all students, employees and contractors who perform work on electrical circuits and equipment operating at voltages 50 volts and above at Penn. 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.

3. DEFINITIONS

Approved – Acceptable to the authority having jurisdiction (AHJ).

Authorized Lockout/Tagout Employee - A person who has completed the required hazardous energy control training and is authorized to lock or tag out a specific machine or equipment to perform service or maintenance. A person must be certified as an Authorized Lockout/Tagout Employee in order to apply a lock or tag to control hazardous energy. All authorized lockout/tagout employees must be trained.

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

Arc Flash Risk Assessment - A study investigating a worker's potential exposure to arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices and the appropriate levels of personal protective equipment.

Arc Rating – The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (E_{BT}) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.

Arc Thermal Performance Value (ATPV) - The highest incident energy which did not cause a fire resistant fabric to break open and did not exceed the second degree burn criteria.

Boundary, Arc Flash – When an arc flash hazard exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur.

Boundary, Electrical Safety – The minimum distance Qualified Persons should keep unqualified workers away. Inside this boundary, individuals must be Qualified and must be wearing all appropriate personal protective equipment. This boundary encompasses the Arc Flash Boundary and Restricted Approach Boundary.

Boundary, Limited Approach – An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists. This is the closest distance an Unqualified Person can approach and can be crossed only by Qualified Persons. Crossing this boundary is considered "working near energized parts".

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

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

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

Competent Person – A person who meets all the requirements of Qualified Person and who in addition, is responsible for all work activities or safety procedures related to custom or special equipment and has detailed knowledge regarding the exposure to electrical hazards, the appropriate control methods to reduce the risk associated with those hazards, and the implementation of those methods.

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

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

Disconnecting Means - A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnection (or Isolating) Switch (Disconnector, Isolator) – A mechanical switching device used to isolate a circuit or equipment from a source of power.

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

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

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

Enclosed – Surrounded by a case, housing, fence or wall(s) that prevents persons from accidentally contacting energized parts.

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

Energized – Electrically connected to, or is, a source of voltage.

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

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

Field Evaluated – A thorough evaluation of nonlisted or modified equipment in the field that is performed by persons or parties acceptable to the authority having jurisdiction. The evaluation approval ensures that the equipment meets appropriate codes and standards, or is similarly found suitable for a specified purpose.

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

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 exceeds the values established for a Class A device. *Note: Class A GFCI trip when the current to ground is 6 mA or higher and do not trip when the current to ground is less than 4mA.*

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

Grounding Electrode (Conductor) – A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

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

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

Hazardous – Involving exposure to at least one hazard.

Interlock – An electrical, mechanical, or key-locked device intended to prevent an undesired sequence of operations.

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

Incident Energy Analysis – A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

Interrupting Rating – The highest current at rated voltage that a device is identified to interrupt under standard test conditions.

Laboratory – A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostic, product testing, or use of custom or special electrical components, systems, or equipment.

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

Listed – Equipment, materials or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Nationally Recognized Testing Laboratory (NRTL) - An OSHA designation given to third party testing facilities that provide product safety testing and certification services to manufacturers. Please review the OSHA NRTL web page for an inclusive list of NRTLs.

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

Risk Assessment – An overall process that identifies hazards, estimates the potential severity of injury or damage to health, estimates the likelihood of occurrence of injury or damage to health, and determines if protective measures are required. As used in this program, the two types of electrical hazard risk assessments identified are arc flash risk assessment and shock risk assessment.

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

Shock Hazard Risk Assessment – An evaluation investigating a person's potential exposure to energized parts or circuits, conducted for the purpose of injury prevention and the determination of safe work practices and the appropriate levels of personal protective equipment.

Unqualified Person – A person who is not a Qualified Person.

Working On (energized electrical conductors or circuit parts) – Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing. There are two categories of "working on": *Diagnostic* (testing) is taking readings or measurements of electrical equipment with approved test equipment; *repair* is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.)

4. RESPONSIBILITIES

A) Executive Director of EHRS and Designees:

The Executive Director of Environmental Health and Radiation Safety (EHRS) is responsible for the development, implementation, coordination of training, and administration of the Electrical Safety Program.

B) Supervisors/Lead Personnel:

1) Ensure only Qualified Persons work on exposed energized electrical parts and/or equipment.

2) Create standard operating procedures for electrical tasks.

3) Conduct arc flash and shock hazard risk assessments.

4) Conduct Job Briefings prior to hazardous tasks.

5) Ensure employees have and use the proper safety equipment for the job (personal protective equipment, barriers, barricades, cones, etc.)

6) Ensure all new electrical installations installed by Penn employees meet codes and regulations.

C) Employees/Qualified Persons:

1) Understand the hazards and operation of the equipment being worked on.

2) Be familiar with procedures for evaluating how the work will be performed and all options for performing the work using the preferred method while circuits are de-energized.

3) Trained on and understand the proper use of test instruments.

4) Have the skills and techniques necessary to determine nominal voltages of exposed energized parts.

5) Understand the procedures for establishing an electrically safe work condition.

6) Have the skills and techniques necessary to distinguish energized parts from other electrical parts.

7) Maintain safe clearance distances from exposed live electrical parts.

8) Use and properly maintain the required personal protective equipment for the task.

9) Report unsafe conditions or electrical deficiencies immediately to supervisors.

Unqualified Persons must always remain outside the electrical safety boundary when working in the vicinity of exposed energized electrical equipment.

D) Penn as the Host Employer

1) Penn shall inform contract employers of the following:

   a) Known hazards that are covered by Penn's Electrical Safety Program related to the contract employer's work; and that might not be recognized by the contract employer or its employees.
   b) Information about Penn's installation that the contract employer needs in order to make the required assessments.

2) Penn shall report observed contract employer-related violations of NFPA 70E or other safety regulations to the contract employer.

E) Outside Contractors

1) The contract employer shall ensure that each of his or her employees is instructed in the hazards communicated to the contract employer by Penn.

2) The contract employer shall ensure that each of his or her employees follows the work practices required under Penn's safety-related work rules.

3) Must maintain required documentation including permit required confined space, hot work and energized electrical work permits.

4) **Shall not perform any work on energized electrical equipment without prior notification and approval from Penn officials.**

5) Must supply a site-specific safety plan to the Penn project manager or the Penn representative who is coordinating the project.

6) The contract employer shall advise Penn of the following:
   a) Any unique hazards presented by the contract employer's work.

b) Hazards identified during the course of work by the contract employer that were not communicated by Penn.
c) The measures the contractor took to correct any violations reported by Penn.

F) Multi-Employer Responsibility

Where Penn employees and contractors or where multiple contractors are involved with a project, more than one party may be responsible for hazardous conditions or activities that violate safe work practices. Where multiple parties are involved such as a General Contractor with sub-contractors also involved, Penn personnel shall notify the General Contractor that their responsibility extends to each party whereby the parties are informed of; potential hazards, existing hazards, safe work practices, personal protective equipment, emergency procedures, emergency equipment, site requirements and evacuation procedures (applicable for the location and the work being performed). This includes a documented Job Briefing signed by the appropriate representative personnel involved in the project (who are required to participate in the Job Briefing).

5. HAZARD CONTROL

A) Engineering Controls

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

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

3) 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.

4) 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.

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

6) 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-foot side clearance shall be maintained for all distribution panels.

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

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

B) Administrative Controls

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

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

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

4) Only Qualified Persons shall conduct repairs to electrical equipment.

5) Contractors performing electrical work must hold a license for the work.

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

7) All electrical control devices shall be properly labeled.

8) All Qualified Persons will follow established electrical safety procedures and precautions.

9) Conductive articles of jewelry and clothing (such a watch bands, bracelets, rings, key chains, 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.

6. RISK ASSESSMENT PROCEDURE

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 the tasks to be performed.

3) Implement risk control by determining the appropriate protective measures.

See Appendix 1 for sample risk assessment procedures.

7. ESTABLISHING AN ELECTRICALLY SAFE WORK CONDITION (LOCKOUT/TAGOUT)

A) **Working On or Near Electrical Equipment (De-energizing Equipment)**

1) Energized parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works 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 backfeed.

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

The procedure for any properly Qualified Person while working on the circuits is as follows (Utilize the appropriate personal protective equipment and proper voltage-rated tools for these steps):

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

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

3) Whenever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout type circuit breakers are withdrawn to the fully disconnected position.

4) Apply lockout/tagout devices in accordance with Penn's Control of Hazardous Energy (Lockout/Tagout) Program.

5) Use an adequately rated and calibrated 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.

6) 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 ground connecting devices rated for the available fault duty.

C) **Process of Reenergizing Equipment**

In addition to the requirements of Penn's Control of Hazardous Energy (Lockout/Tagout) Program, the following requirements must be met, in the order given, before circuits or equipment are re-energized, even temporarily:

1) 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; and,

2) Employees potentially exposed to the hazards of re-energizing the circuit must be warned to stay clear; and,

3) Each employee removes his or her lock(s) and tag(s).

8. WORK ON EXPOSED ENERGIZED ELECTRICAL EQUIPMENT (PERMIT REQUIRED)

Penn's goal is to perform electrical work after energized electrical conductors and circuit parts are placed into an electrically safe work condition.

Safety-related work practices shall be used to safeguard employees 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 safety-related work practices shall be determined before any person is exposed to the electrical hazards involved by using both shock risk assessment and the arc flash risk assessment. 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.

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

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

A) Working on Energized Parts – Energized Electrical Work

1) Justification to work on energized equipment.

   a) Examples of Additional Hazards or Increased Risk:
      (i) Interruption of life support equipment.
      (ii) Deactivation of emergency alarm systems.
      (iii) Shutdown of hazardous location ventilation equipment.
   b) Examples of infeasibility due to equipment design or operational limitation:
      (i) Diagnostics and testing/troubleshooting that can only be successfully performed with circuit energized.
      (ii) 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.
   c) Normal Operation – Normal operation of electric equipment shall be permitted where all of the following conditions are satisfied:
      (i) The equipment is properly installed.
      (ii) The equipment is properly maintained.
      (iii) All equipment doors are closed and secured.
      (iv) All equipment covers are in place and secured.
      (v) There is no evidence of impending failure.

B) Energized Electrical Work Permit (See Appendix 3)

1) When Required – When energized work is permitted in accordance with the criteria listed above, an energized electrical work permit shall be required 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.

The work permit shall include the following items:

1) A description of the circuit and equipment to be worked on and the location.

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

3) Determination of shock and arc flash protection boundaries.

4) The necessary personal protective equipment to safely perform the assigned task.

5) A description of the safe work practices to be employed.

6) Means employed to restrict the access of Unqualified Persons from the work area.

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

8) Energized work approval signatures.

C) 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 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.

   Examples:

   a) Thermography and visual inspection up to restricted approach boundary.
   b) Access/egress with no electrical work up to restricted approach boundary.
   c) General housekeeping up to restricted approach boundary.

D) Job Briefings

An example job briefing checklist is included in Appendix 4.

1) The employee 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.

2) 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 employees, occur during the course of the work.

3) Extent of Briefings: A brief discussion shall be satisfactory if the work involved is routine and if the employee, 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 employee cannot be expected to recognize and avoid the hazards involved in the job.
   c) Employees working alone need not conduct a pre-job briefing; however, the Supervisor shall ensure that the tasks to be performed are planned as if a briefing were required.

E) 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 the Safe Work Rules (see Appendix 7) are followed while performing energized electrical work.

9. PERSONAL PROTECTIVE EQUIPMENT (PPE) & TOOLS

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, the employee 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 worker injury from shock, arc flash and other hazards.

A) Shock Protection – workers shall conduct a Shock Hazard Risk Assessment and shall select and utilize the appropriate PPE and voltage-rated tools. Crossing the Restricted Approach Boundary requires PPE.

Effects of Electricity on the Human Body.

The employer and employees shall be aware of the following hazards associated with power electronic equipment.

1) Effects of Power Frequency Current:

   a) At 0.5 mA, shock is perceptible.
   b) At 10 mA, a person may not be able to voluntarily let go of an energized electrical conductor or circuit part.
   c) At about 40 mA, the shock, if lasting for 1 second or longer, can be fatal due to ventricular fibrillation.
   d) Further increasing current leads to burns and cardiac arrest.

2) Effects of DC Current:

   a) A DC current of 2 mA is perceptible.
   b) A DC current of 40 mA is considered the threshold of the let-go current.

3) Effects of Voltage

   a) A voltage of 30 V rms, or 60 V dc, is considered safe, except when the skin is broken. The internal body resistance can be as low as 500 ohms, so fatalities can occur.

Rubber Insulated Gloves - Employees shall wear rubber insulated gloves for the highest phase to phase or phase to ground (whichever requires higher voltage class glove) voltage that the worker will be exposed to 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.

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.

Penn employees who work with electrical equipment will be issued a pair of insulated gloves for work. These gloves must be tested every six months. Rubber gloves shall be evaluated for leaks before each use. Heavy-duty protective leather gloves (protectors) shall be worn over the rubber-insulated gloves for work. Any insert or cover showing defects should be replaced and destroyed immediately.

Rubber Insulated Gloves Voltage Requirements:

Class	Maximum AC Voltage	Maximum DC Voltage
Class 00	500 volts	750 volts
Class 0	1,000 volts	1,500 volts
Class 1	7,500 volts	11,250 volts
Class 2	17,000 volts	25,500 volts
Class 3	26,500 volts	39,750 volts
Class 4	36,000 volts	54,000 volts

Tests of Rubber Gloves - Rubber gloves and sleeves shall be maintained as per the current ASTM F496 Standard Specification for In-Service Care of Insulating Gloves and Sleeves and shall be electrically tested at least once every six months after they are checked out for use, and complete records shall be kept of all such tests and date of issue. Rubber gloves not checked out for use within twelve months shall be retested before being issued.

B) Arc Flash Risk Assessment

1) An arc flash risk assessment shall be performed and shall:

   a) Provide safety-related work practices.
   b) Define the arc flash boundary.
   c) Specify the PPE to be used within the arc flash boundary.
   d) 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.
   e) Take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance.

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

C) Arc Flash Boundary

1) The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm^2.

2) The arc flash boundary shall be determined by use of the table in Appendix 11 or as defined by an Incident Energy Analysis.

D) Arc Flash PPE

1) 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.

   a) Incident Energy Analysis Method – The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Arc-rated clothing and other PPE shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the

distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the distance at which the incident energy was determined.

b) Arc Flash PPE Categories Method – If the equipment does not have an arc flash 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 may be determined from consulting Appendices 10 and 11 of this program along with a thorough risk assessment. If the equipment parameters defined in Appendix 11 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 12).

Note: Appendix 11 and the Hazard Risk Categories/Arc Flash PPE Categories listed directly below and Appendix 12 only account for equipment where the maximum anticipated exposure level is 40 cal/cm^2. Penn employees shall not work on energized equipment where the maximum anticipated exposure level exceeds 40 cal/m^2 (typically referred to as "Dangerous" by an Incident Energy Analysis/label).

2) Hazard Risk Category (HRC)/Arc Flash PPE Categories:

a) **HRC PPE Category 0: < 1.2 cal/cm^2**
Clothing – Long sleeve shirt and long pants made of nonmelting or untreated natural fiber (i.e., untreated cotton) with a fabric weight of at least 4.5 oz./square yard.
PPE - safety glasses or safety goggles, hearing protection (ear canal inserts), voltage rated gloves with leather protectors.

b) **HRC/Arc Flash PPE Category 1: Minimum Arc Rating of 4 cal/cm^2**
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.
PPE – Class E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.

c) **HRC/Arc Flash PPE Category 2: Minimum Arc Rating of 8 cal/cm^2**
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.
PPE – Class E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.

d) **HRC/Arc Flash PPE Category 3**: **Minimum Arc Rating of 25 cal/cm^2**
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.
PPE – Class E hard hat, safety glasses or safety goggles, hearing protection, (ear canal inserts), leather footwear.

e) **HRC/Arc Flash PPE Category 4 (Minimum Arc Rating of 40 cal/cm^2).**
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.
PPE – Class E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), leather footwear.

3) **Layering** – Nonmelting, flammable fiber garments shall be permitted to be used as underlayers in conjunction with arc-rated garments in a layered system. If nonmelting, 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.

4) **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/cm^2. Toe guards and structural components shall be constructed of Structurally Engineered Moldable Composite (SEMC) Certified materials. Steel toe and component shoes are not allowed.

5) **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.

6) **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.

7) **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.

8) **PPE Care and Inspection –** PPE shall be maintained in a safe 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.

   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.

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

10. ELECTRICAL INSTALLATION REQUIREMENTS

A) Labeling/Signage

1) Doors into electrical control panel/equipment rooms/vaults shall be conspicuously marked with a plainly visible and legible sign stating "DANGER – HIGH VOLTAGE – KEEP OUT"

B) Identification of Disconnecting Means and Circuits

1) Each disconnecting means for motors and appliances shall be legibly marked to indicate its purpose. The label or marking should be located at the point where the circuit originates. For example, on a panel that controls several motors or on a motor control center, each disconnect must be clearly marked to indicate the motor to which each circuit is connected.

2) Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose.

3) All labels and markings must be durable enough to withstand weather, chemicals, heat, corrosion, or any other environment to which they may be exposed.

C) Working Distances

Working space for equipment likely to require examination, adjustment, servicing, or maintenance while energized shall comply with the dimensions prescribed by National Electrical Code (NFPA 70): Section 110.26 (< 600 volts) or Section 110.32 (>600 volts) that is in effect at the time of installation.

D) General Wiring Design and Protection

New electrical wiring, and the modification, extension or replacement of existing wiring must conform to the requirements of the National Electrical Code (NFPA 70) and applicable OSHA standards.

E) Examination

1) Electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees.

2) Safety of equipment shall be determined using the following considerations:

   a) Suitability for installation and use.
   b) Suitability of equipment for an identified purpose may be evidenced by listing or labeling for that identified purpose.
   c) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.
   d) Electrical insulation.
   e) Heating effects under conditions of use.

f) Arcing effects.
g) Classification by type, size, voltage, current capacity, and specific use.
h) Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.

F) Requirements for Temporary Wiring and Flexible Cords

Temporary electrical power and lighting installations 600 volts or less, including flexible cords, cables and extension cords, may only be used during and for renovation, maintenance, repair, or experimental work. The following additional requirements apply:

1) Ground-fault protection (e.g., ground-fault circuit interrupters or GFCI) must be provided on all temporary-wiring circuits, including extension cords, used on construction sites or in potentially damp or wet locations.

2) In general, all equipment and tools connected by cord and plug must be grounded. Listed or labeled double-insulated tools and appliances need not be grounded.

3) Feeders must originate in an approved distribution center, such as a panelboard, that is rated for the voltages and currents the system is expected to carry.

4) Branch circuits must originate in an approved power outlet or panelboard.

5) Neither bare conductors nor earth returns may be used for the wiring of any temporary circuit.

6) Receptacles must be of the ground fault-grounding type. Unless installed in a complete metallic raceway, each branch circuit must contain a separate equipment-grounding conductor, and all receptacles must be electrically connected to the grounding conductor.

7) Suitable disconnecting switches or plug connects must be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

8) Lamps for general illumination must be protected from accidental contact or damage, either by elevating the fixture eight feet or more above the floor or work surface or by providing a suitable guard. Handlamps supplied by flexible cord must be equipped with a handle of molded composition or other approved material and must be equipped with a substantial bulb guard.

9) Flexible cords and cables must be of an approved type and suitable for the location and intended use. They may only be used for pendants, wiring of fixtures, connection of portable lamps or appliances, elevators, hoists, connection of stationary equipment where frequently interchanged, prevention of transmission of noise or vibration, data processing cables, or where needed to permit maintenance or repair. Flexible electric cords may not be utilized for raising or lowering equipment. They may not be used as a substitute for fixed wiring, where run through holes in walls, ceilings or floors, where run through doorways, windows or similar openings, where attached to building surfaces, or concealed behind building walls, ceilings or floors.

10) Flexible cords and cables must be protected from accidental damage. Sharp corners and projections are to be avoided. Flexible cords and cables must be protected from damage when they pass through doorways or other pinch points.

11) Flexible cords must be connected directly to a receptacle. They may not be connected in series or in conjunction with relocatable power taps (power strips).

12) Extension cords used with portable tools must be three-wire type no smaller than 16-3 gauge. Extension cords must be inspected prior to use and all cords found with frayed or otherwise damaged cord jacketing, or missing the ground pin must be removed from service and either destroyed or repaired by a Qualified Person.

13) Wrapping electrical tape around a damaged flexible cord or extension cord jacketing is not a suitable repair. Once the outer jacket has lost its integrity, tape does not provide the required protection for the inner conductors. Tape does not restore the original integrity of the jacket; therefore the cord must be destroyed and discarded or properly repaired or replaced.

14) Relocatable power taps (power strips) shall be of the polarized or grounded type and be equipped with overcurrent protection and shall be listed. Relocatable power taps must be connected directly to a receptacle. They may not be used in conjunction with extension cords.

15) The use of multiplug adaptors, such as cube adaptors, are prohibited.

G) Free from Recognized Hazards

Electrical equipment must be free from recognized hazards that are likely to cause death or serious physical harm. Equipment must be suitable for the installation and use, and must be installed and maintained in accordance with the manufacturer's instructions, the National Electrical Code (NEC) and the applicable Occupational Safety and Health Administration (OSHA) Standards.

This includes:

- doors are closed and secured
- covers are in place and secured
- no evidence of impending failure

H) Guarding of Energized Parts

Energized parts of electrical equipment operating at 50 volts or more must be guarded against accidental contact. Proper guarding can be achieved by use of an approved enclosure, by location in a room or vault that is accessible to Qualified Persons only, or by elevating the equipment or controlling the arrangement of the space to prevent contact by Unqualified Persons. If electric equipment is located in an area where it is potentially exposed to physical damage, the enclosure or guard must be of sufficient strength to prevent such damage.

I) Electric Power and Lighting Circuits

1) **Routine Opening and Closing of Circuits** - Load rated switches, circuit breakers, or other devices specifically designed as disconnecting means must be used for the opening, reversing, or closing of

circuits under load conditions. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections may not be used for opening, reversing, or closing circuits under load conditions.

2) **Re-Closing Circuits After a Protective Device Operates** - After a circuit is de-energized by a circuit protective device (e.g., circuit breaker or similar), one reset will be allowed by a properly qualified employee. If the problem still exists, the problem must be communicated to a supervisor before the circuit can be reset again. The repetitive manual re-closing of circuit breakers or re-energizing circuits by replacing fuses without verifying that the circuit can be safely energized is prohibited.

3) Overcurrent protection of circuits and conductors may not be modified, even on a temporary basis.

J) Test Equipment and Instruments

1) Only Qualified Persons may perform testing work on electric circuits or equipment. Test instruments and equipment (including all associated test leads cables, power cords, probes and connectors) must 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 must be tagged out of service. The device may not be returned to service until it has been repaired and tested safe for use.

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

3) Test equipment utilized by Penn students and employees shall be supplied and maintained by Penn and have a minimum rating of Category III for testing equipment rated at 600 volts or less.

4) Before and after each test, determine that the test instrument is operating satisfactorily through verification on a known voltage source.

5) Voltage testing instruments shall be maintained and calibrated according to the manufacturer's specifications.

K) Overhead Power Lines

1) If work is to be performed near energized overhead lines, the lines must be de-energized and grounded. If the lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the electric circuits involved to de-energize and ground them.

2) A ground safety person shall be designated if equipment must be operated in the vicinity of overhead power lines that are not de-energized. This person's responsibility is to observe that safe working clearances are maintained around all overhead lines and to direct the equipment operator accordingly.

3) When an unqualified person is working either in an elevated position or at ground level near energized overhead lines, the location of the employee and the longest conductive object being used must not come closer than ten feet from the overhead line.

4) All vehicular and mechanical equipment operating in the vicinity of energized overhead electrical lines must not approach the lines any closer than ten feet. Penn employees standing on the ground near equipment operating near overhead lines must stay ten feet clear of the operating equipment.

L) General Precautions

1) **Illumination -** Sufficient illumination must be provided at the work site when working near exposed energized electrical equipment.

2) **Confined or Enclosed Space** - Employees required to work in confined or enclosed spaces where there is electrical equipment must receive specialized training on the hazards/risks involved. Work must be completed in compliance with the applicable Penn Permit Required Confined Space Program.

3) **Ladders** - All portable ladders used for electrical-related work must have non-conductive side rails and shall be compliant with ANSI A14 standards.

4) **Conductive Materials and Equipment** - Conductive apparel (jewelry, watches, rings, necklaces, bracelets) must not be worn within the electrical safety boundary.

5) **Housekeeping** - Proper clearances must be maintained around electrical equipment.

6) **Flammable or Ignitable Materials** - Where flammable or ignitable materials are present, do not use electric equipment capable of igniting them unless measures are taken to prevent hazardous conditions from developing. Flammable and ignitable materials include, but are not limited to, flammable gases, vapors, or liquids, combustible dust, and ignitable fibers or filings. Equipment that is intrinsically safe for the hazardous condition may be used.

M) Alerting Techniques

The following alerting techniques must be used to warn and protect employees from electrical shock hazards, burns, or failure of electric equipment parts.

1) **Safety Signs and Tags** - Safety signs, safety symbols, or accident prevention tags are to be used where necessary to warn employees about electrical hazards that may endanger them.

2) **Barricades** – Barricades are used in conjunction with safety signs where 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. Where the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary.

3) **Attendants** - If signs and barricades do not provide sufficient warning from electrical hazards, an attendant is to be stationed to warn and protect employees. Attendants can also be used for short-term energized work. Example: Utilize attendant while Qualified Person is temporarily exposed to energized parts.

N) Safety Related Maintenance Requirements

1) Electrical equipment shall be maintained in accordance with the manufacturers' instructions or industry consensus standards to reduce the risk associated with failure.

11. RESEARCH LABORATORIES and SUPPORT SHOPS

This section defines practices and procedures to be implemented for electrical equipment that is not listed or labeled by a nationally-recognized testing laboratory (NRTL). Typically, this will include research related equipment that is custom built in-house or NRTL-listed or labeled equipment that has been modified which invalidates the listing or labeling.

A) General

1) Equipment and installations that bear the seal of a NRTL are considered approved as long as they are installed and used in accordance with any instructions included in the listing or labeling.

2) NRTL-listed or labeled equipment must be acquired/used whenever it is available, even if similar unlisted or labeled equipment can be used. OSHA allows for approval of custom-made equipment or related installations if the equipment is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection.

3) Electrical equipment fabrication, modification or installations shall be completed by or under the direct supervision of a Competent Person.

4) A Competent Person is person who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved. The Competent Person is responsible for all work activities or safety procedures related to custom or special equipment and has detailed knowledge regarding the exposure to electrical hazards, the appropriate control methods to reduce the risk associated with those hazards, and the implementation of those methods.

5) Where electrical equipment must be custom fabricated because listed or labeled equipment is not available or there is a case where foreign equipment is acquired to perform a unique experimental function in support of the laboratory's scientific mission or there is a need for continued use of legacy equipment, the equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees. The equipment must be Field Evaluated and approved by a Competent Person and documented on the form included in Appendix 13.

B) Equipment Examination - In judging equipment, considerations such as the following shall be evaluated:

1) Suitability of equipment for an identified purpose may be evidenced by listing or labeling for that identified purpose.

2) Electrical equipment must be enclosed to protect personnel from the hazards of electrical shock and arc flash and to contain fire or pieces that could be violently expelled.

3) Exposed metal parts of the enclosure are bonded and grounded.

4) Appropriate overcurrent protection is installed.

5) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

6) Wire-bending and connection space.

7) Electrical insulation.

8) Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service.

9) Arcing effects.

10) Classification by type, size, voltage, current capacity, and specific use.

11) Openings through which conductors enter shall be adequately closed and strain relief provided.

12) Other factors that contribute to the practical safeguarding of persons using or likely to come in contact with the equipment.

C) Approval Process

1) The fabricator must arrange for Field Evaluation of the fabricated or modified electrical equipment. The equipment must be inspected and approved by a Competent Person.

2) Documentation: The following documents must be maintained by the equipment fabricator:
   a) Justification for in-house modifications of NRTL listed or labeled equipment or need for in-house fabrication of equipment.
   b) Design information and a schematic line drawing of the electrical work.
   c) Qualifications of the fabricator. Qualifications include adequate technical electrical/electronic and electrical safety knowledge.
   d) Completed Custom Built or Modified Equipment Inspection & Approval Form (Appendix 13). The form must be maintained for the life of the equipment.

12. HAZARDOUS LOCATIONS

A) Wet or Damp Locations

1) Work in *wet* or *damp* work *locations* (i.e., areas surrounded or near water or other liquids) should not be performed unless it is absolutely critical.

2) Electrical work should be postponed until the liquid can be cleaned up. If the work cannot be avoided, the Electrical Supervisor responsible for the task, prior to performing the work must grant approval.

3) Every attempt should be made to provide an insulated workspace if the work must be performed.

4) The following special precautions must be incorporated while performing work in *damp locations*:

   a) Only use electrical cords that have Ground Fault Circuit Interrupters (GFCIs);
   b) Place a dry barrier over any wet or damp work surface;
   c) Remove standing water before beginning work. Work is prohibited in areas where there is standing water;
   d) Do not use electrical extension cords in wet or damp locations; and
   e) Keep electrical cords away from standing water.

B) Underground Electrical Installations

1) All work for Underground Electrical Installations falls under the appropriate Penn Permit Required Confined Space Program. Additional requirements for working in electrical manholes or sub-surface vaults are as follows:

   a) Ladders shall be used to enter and exit manholes or sub-surface vaults ≥ 4-feet in depth. No employee may climb into or out of a vault by stepping on cables or hangers.
   b) Equipment used to lower equipment and materials into manholes or vaults shall be capable of supporting the weight of the materials and shall be inspected prior to use for defects. When equipment is lowered, each employee shall be clear of the area directly under the opening.
   c) While work is being performed in a manhole containing energized electrical equipment, employee(s) with First Aid and CPR Training shall be available on the surface in the immediate vicinity to render emergency assistance.

C) Stationary Lead-Acid Battery Systems

1) Signage
   a) Doors and entryways into rooms or areas containing stationary lead-acid battery systems that have a capacity of more than 50-gallons of electrolyte shall be provided with approved signs. The signs shall state that the room contains lead-acid battery systems, that the battery room contains energized electrical circuits and that the battery electrolyte solutions are corrosive liquids.

2) Emergency Irrigation Equipment
   a) An emergency eyewash facility shall be available in the immediate area. A temporary portable eyewash unit is to be made available when servicing batteries if the permanent eyewash station is not operational. Should electrolyte come in contact with eyes, flush liberally with large amounts of water for fifteen minutes and secure medical treatment immediately. Prior to starting work, ensure that the expiration dates on the eyewash solution containers are not expired.

3) The following equipment shall be available to all personnel working with flooded cell batteries:
   a) Safety glasses, goggles and approved face shield.
   b) Acid-resistant gloves for handling batteries.
   c) Protective apron or acid-resistant battery suit and overshoes.
   d) Rubber gloves rated for the possible voltage exposure and heavy-duty leather protector gloves.

e) Insulated tools.
f) Electrolyte neutralizing kit.

4) Wear personal protective equipment including eye/face protection, gloves and aprons or battery suits and non-conductive safety toe boots when handling electrolyte and /or moving batteries. Electrolyte is extremely corrosive.

5) Remove all jewelry (watches, rings, necklaces, etc.) & keys before working with batteries.

6) Use insulated tools if any work must be done on or around the battery.

7) Batteries store electrical energy, so they may prove to be a hazard if mishandled. As in any work involving "energized" equipment, remember to insulate and isolate prior to performing work.

8) Observe proper polarity connections at all times.

9) Ensure unobstructed egress from the battery area at all times when testing.

10) Adequate ventilation shall be provided to remove explosive hydrogen gasses that are generated during battery charging.

11) Flame arresters should be installed on all batteries.

12) No smoking or open flame shall be permitted near a battery.

13) Solvents, detergents and lubricants can damage the plastic compounds used in the battery case and covers. Use of chemical solvents and lubricants shall therefore be limited to specific, approved materials. Do not scratch or otherwise damage the battery cases.

14) Batteries store high amounts of energy. A short circuit across the terminals of a battery can produce arcing and possibly an explosion. Adequate precautions must be taken to prevent short-circuiting battery terminals. Keep the top of the battery clear of tools and other foreign objects at all times.

15) Use suitable fuse leads for short circuit protection during all testing. Extremely high currents are available from a battery. Even an apparently dead cell should never be short-circuited.

16) Cells connected in series have "high voltages" that could present a shock hazard.

17) Directly shorting a cell or portion of a cell with a jumper to keep the DC circuit complete must not be done.

18) Workers may accumulate static charge, especially on dry days, so touch a grounded surface before touching a cell post.

19) Transporting Batteries:

a) Use proper materials handling and lifting techniques.
b) Use carts as much as possible to minimize the need to carry batteries.
c) Never lift or move a battery by its cell posts. Use lifting devices of adequate capacity when required. Inspect all lifting equipment before use.

20) Visually check to insure metal battery racks are properly connected to station ground.

21) Load test leads shall be connected with sufficient lengths to prevent accidental arcing in the battery area.

22) Avoid arcing in the immediate vicinity of the battery.

23) When mixing electrolyte, the acid shall always be added to the water, never the reverse, as this may result in an explosion.

D) Working at Elevated Locations

1) Any person working on electrical equipment on an elevated surface must take necessary precautions to prevent a fall from reaction to electrical shock or other causes.

2) Portable ladders shall have non-conductive side-rails if they are used where the employee or the ladder could contact exposed energized parts. Metal ladders are not permitted. All ladders shall be in compliance with applicable ANSI A14 standard.

E) Bucket Trucks

1) This section refers specifically to vehicle mounted boom lifts (bucket trucks). The use of other types of elevating work platforms are covered under the following separate Penn safety programs:
Boom-Supported Elevating Work Platform Program
Vertical Plane Elevating Work Platform Program

2) Only individuals who have received training on the safe operation of the bucket truck and the specific fall protection requirement are authorized to operate or ride in the bucket.

3) Bucket trucks shall be inspected by the operator prior to use, according to the inspection checklist called for in the instruction manual issued by the manufacturer. Special attention should be given to the following:

a) Inspect hydraulic hoses and controls for twisting, chafing, and proper adjustment.
b) With oil lines under pressure, inspect all hydraulic fittings, pumps, and cylinders for evidence of leakage.
c) Check the unit for proper operating speed and rate of drift.
d) Check the operation of all controls through their maximum working range.
e) Check the booms for cracked welds or distorted members.
f) Check the boom and leveling wire-rope cable for frayed strands, security of terminals, and correct adjustment.

g) Check for the proper inflation and condition of all tires; an under inflated tire or blown tire will affect the stability of the truck. Operations shall be suspended if test or inspection indicates malfunction of equipment which prevents safe operation.

4) All routine and periodic inspections/maintenance must be completed as required by the operator's manual.

5) A warm up period is needed at the beginning of each day's work for hydraulic equipment. This time may vary with different makes and models and ranges of temperatures at various locations.

6) Bucket trucks shall only be used to do such work as can be done without exceeding the posted safe load limits set by the manufacturer.

7) A Ground Safety Person shall be designated to watch for and alert pedestrians of the vehicle while it is moving or in operation where pedestrians are present and to delineate a pedestrian-free area around the vehicle and under the work area using cones, barricades or other methods. The Ground Safety Person also acts as a spotter to warn the operator to stay clear of overhead conductors or other hazards.

8) Careful consideration shall be given to the location of overhead conductors and the surrounding conditions before the truck is moved into the work position. Every attempt should be made to place the truck so that all work areas at that location might be reached by the boom without additional movement of the truck.

9) All vehicular and mechanical equipment operating in the vicinity of energized overhead electrical lines must not approach the lines any closer than ten feet. Penn employees standing on the ground near equipment operating near overhead lines must stay ten feet clear of the operating equipment.

10) The truck shall be stabilized before the boom is un-cradled. The brakes shall be set and outriggers, when included, shall be positioned on pads. Wheel chocks shall be installed when working on an incline.

11) When working on inclined surfaces, the truck shall be checked to make sure a stable setup has been arranged. The truck should sit approximately level as viewed from the rear.

12) Before lowering the stabilizers, outriggers, or hydraulic jacks, the operator shall be certain the area is clear and that no one is in a position where they may be injured by the equipment.

13) The operator shall follow the proper sequence prescribed by the manufacturer in raising the boom section.

14) When moving the boom, employees shall stand clear of the boom travel path.

15) Riding in the basket when vehicle is in motion shall not be permitted.

16) Belting off to an adjacent pole, structure, or equipment while working from a bucket truck shall not be permitted.

17) Employees shall always stand firmly on the floor of the bucket, and shall not sit or climb on the edge of the basket or use planks, ladders, or other devices for a work position.

18) Equipment or material shall not be passed between a pole or structure and a bucket truck while an employee working from the basket is within reaching distance of energized conductors or equipment that are not covered with insulating protective equipment.

19) Winch lines, bull lines, straight lines or conductors shall not be secured to the upper boom or basket of an aerial lift during operations. However, a hand-line may be attached to raise and lower protective equipment, hand tools and light material. The hand-line shall first be detached when it is necessary to maneuver the basket more than a short distance.

20) The insulated parts of an aerial lift device shall not be altered with any material that might reduce its insulating value. Only attachments authorized by EHRS shall be installed on the basket or boom assembly.

21) The operator in the basket of a bucket truck shall always face in the direction in which they are moving.

22) The employee shall disconnect air or hydraulic tools from the power supply when not in use.

23) The use of cord fed electrical tools from the basket shall not be permitted.

24) Amber safety beacon lights shall be on when the vehicle is in operation.

25) Bucket trucks with insulated arm(s) shall be electrically tested annually in accordance with a pre-arranged schedule.

26) Storage of tools and materials on the cab guards of bucket trucks shall be kept to a minimum. Care shall be taken to avoid overloading of the cab guard and unobstructed access to and from the basket shall be maintained.

27) Any repair of the hydraulic pressure system, (involving opening of the pressure lines), shall only be completed by the vehicle service provider.

28) Work shall be discontinued when adverse weather conditions would make the work hazardous in spite of safe work practices. Examples of adverse weather conditions are thunderstorms in the immediate vicinity, high winds, snowstorms, and ice storms.

13. EMERGENCY PROCEDURES

A) In case of emergency:

1) For emergencies occurring on the main Penn campus, call 511 from a campus phone or (215) 573-3333.

2) Morris Arboretum, New Bolton Center or anyone working off the main campus must contact 911 to summon help.

3) Stay with the individual until help arrives. Notify the appropriate supervisor and EHRS (215) 898-4453 as soon as possible after the injury occurs.

B) Minor Injuries:

1) **Main Campus** – Seek treatment during the hours 8:00 AM – 3:30 PM at HUP - Occupational Medicine located in the Ravdin Building Second Floor located at 3400 Spruce Street. After these hours, seek treatment at HUP Emergency Service located on the Ground floor of the Silverstein Pavilion at 34th and Spruce Streets.

2) **New Bolton Center** – Seek treatment at Occupational Health Center of Kennett Square located at 830 West Cypress Street, Kennett Square, 19348 (610) 444-6214 or Chester County Hospital located at 701 East Marshall Street, West Chester, 19380 (610) 444-5000 or Jennersville Regional Hospital located at 1015 West Baltimore Pike, West Grove, PA 19390 (610) 869-1000

3) **Morris Arboretum** – Seek treatment at Chestnut Hill Hospital located at 8835 Germantown Ave. Philadelphia, PA 19118 (215) 248-8200

4) Other Locations – Seek treatment at closest Emergency Department.

14. TRAINING

A) Qualified Persons

1) Supervisors are responsible for identifying and coordinating specialized technical training required for their employees.

2) All Qualified Persons must be trained in Penn's Electrical Safety Program initially upon assignment and periodically not to exceed a three year period.

3) Qualified Persons working on exposed lines or equipment on power generation, transmission and distribution systems energized at 50 volts or more shall be trained in first aid and cardiopulmonary resuscitation (CPR).

4) An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a Qualified Person is considered to be qualified for the performance of those duties.

5) For an individual to be qualified on a specific activity, the employee must be trained on that work activity or provide documentation which demonstrates the employee's ability to safely perform the work activity.

6) Contact Release: Employees exposed to shock hazards shall be trained in methods of safe release of victims from contact with exposed energized parts. This training shall occur annually.

B) Unqualified Persons

1) All Unqualified Persons who may potentially encounter electrical hazards shall be trained to identify electrical hazards to which they could be exposed and the proper methods of avoiding the hazards. This training should occur upon assignment and periodically not to exceed a three year period.

2) Unqualified personnel shall be instructed in the following:

   a) Risk and hazards associated with contact with energized electrical equipment, and
   b) Tasks that can only be performed by a Qualified Person, and
   c) Importance of electrical hazard signs, labels and tags.

15. ELECTRICAL SAFETY PROGRAM AUDITING

A) The Electrical Safety Program shall be evaluated by an audit team, consisting of a representative from EHRS and at least one Qualified Person every three years or earlier if an accident or near miss occurs. The Electrical Safety Audit Checklist may be used to assist this process. (Appendix 8)

1) If the audit uncovers a deficiency, the team can formulate a resolution and recommend a revision to the program. The revision should involve the workers that are affected to ensure that the resolution addresses all of the known hazards and does not create an additional hazard.

2) After the procedure has been revised, the workers affected by the revision shall be retrained.

16. OTHER ITEMS

A) Accidents and Near Misses

Accidents and Near Misses must be documented (see appendix 9). Information that must be documented includes the following:

1) Employees Involved. List names of all employees assigned to the job. List qualifications of employees.

2) Job Location: Area and Electrical equipment identification of circuit; this should include a description of the circuit and equipment that was involved.

3) Description of work performed. This should include a description of the safe work practices that were employed or violated.

4) Determination of shock and arc flash protection boundaries according to the Risk Assessment.

5) The necessary personal protective equipment to safely perform the assigned task.

6) Means employed to restrict the access of unqualified persons from the work area.

7) Evidence of completion of a job briefing, including a discussion of any job specific hazard.

8) A copy of the completed Energized Work Permit (if applicable).

9) Equipment details.

10) Sketches/pictures.

11) Reference data.

17. REFERENCES

A) Code of Federal Regulations 29 CFR 1910.269, "Electrical Power Generation, Transmission and Distribution"

B) Code of Federal Regulations 29 CFR 1910.137, "Electrical Protective Devices"

C) Code of Federal Regulations 29 CFR 1910.147, "The Control of Hazardous Energy"

D) Code of Federal Regulations 29 CFR 1910.331, 1910.332, 1910.333, 1910.334, 1910.335, "Electrical Safety Work Practices".

E) National Fire Protection Association (NFPA) NFPA 70 – National Electrical Code

F) National Fire Protection Association (NFPA) NFPA 70E, Standard for Electrical Safety in the Workplace, 2015 Edition

G) University of Pennsylvania Control of Hazardous Energy (Lockout/Tagout) Program

H) University of Pennsylvania Electrical Safety Fact Sheet

I) University of Pennsylvania Materials Handling and Lifting Fact Sheet

J) University of Pennsylvania Elevating Work Platform Programs

K) University of Pennsylvania Confined Space Programs

L) City of Philadelphia Fire Code

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.

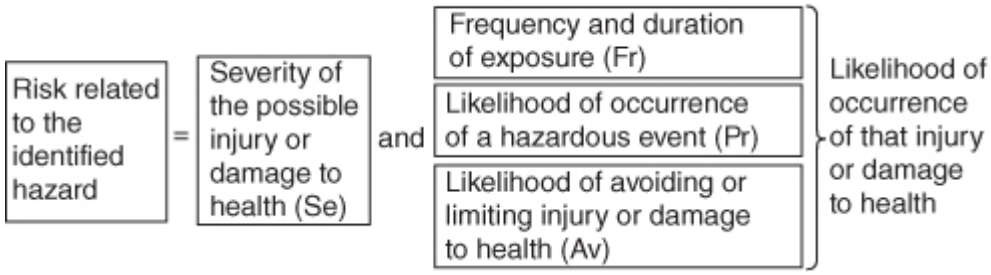


Figure 1 Elements of Risk

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:

1. 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)

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

Table 1

2. 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
    b. 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)

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

Table 2

3. 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.

    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.

    This parameter can be estimated by taking into account 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 taken into account. 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.

b. 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:
    i. Stress (e.g., due to time constraints, work task, perceived damage limitation).
    ii. 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).

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

Table 3

Listed below are examples of general questions to consider in determining the likelihood of an event (risk):

- Has the equipment been installed in accordance with *NFPA 70®, National Electrical Code® (NEC®)*?
- Has the equipment been maintained and tested in accordance with the manufacturer's instructions?
- How old is the equipment?
- Is there any visual indication of overheating?
- Is any component, device, or equipment loose or damaged?

The following are enclosure questions:

- Do all enclosure doors operate and latch properly?

- Does the enclosure have all of its bolts and screws installed?
- Does the equipment or enclosure have ventilation openings?
- Is the enclosure arc rated?
- Are there openings in the enclosure that rodents or other vermin could enter?
- Is there an indication of moisture in the equipment?
- Has the enclosure been examined for dust, dirt, soot, or grease?
- Is there any indication of overheating of the bus work, etc., in the enclosure, such as discoloration?

The following are circuit breaker (CB) condition questions:

- Has the CB periodically been operated in accordance with the manufacturer's instructions?
- Has the CB been applied within its marked rating?
- Has the right type of CB been used?
- Have the proper conductor types and sizes been used to connect to the CB?
- Has the CB been checked for burn marks?
- Have the CB surfaces been examined for dust, dirt, soot, grease, or moisture? If any was found, have the CB surfaces been appropriately cleaned?
- Has the CB been examined for cracks?
- Have all electrical connections to the CB been checked to be certain that they are clean and secure?
- 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?
- Is there any evidence of overheating or melting of the arc chute vent or area surrounding the vents?
- Is there evidence of overheating or case blistering?
- If the CB has interchangeable trip units, have the trip units been visually checked for overheating or looseness?
- Have mechanical operation tests been performed on the CB and proper contact operation verified?
- Have insulation resistance and/or individual pole resistance (millivolt drop) tests been performed on the CB?
- Have inverse-time and/or instantaneous overcurrent trip tests been conducted on the CB?
- What is the ampere rating of the CB involved?

4. Likelihood of Avoiding or Limiting Injury or Damage to Health (Av) – This parameter can be estimated by taking into account 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:
    a. Sudden or gradual appearance of the hazardous event; for example, an explosion caused by high fault values under short-circuit conditions.
    b. Spatial possibility to withdraw from the hazard.
    c. 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.
    d. 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).

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

Table 4

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

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

Table 5

A Risk Score (R) higher than 10 requires consideration of additional safety controls.

Risk Matrix Method

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.

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.

	Severity of the injury (consequences)				
Likelihood of occurrence in period	**Slight**	**Minor**	**Medium**	**Critical**	**Catastrophic**
Cal/cm^2	< 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

Figure 2 Risk Assessment Matrix

3. **Interpretation of Risk Assessment Matrix:**
    a. **Extreme (E) - Intolerable risk:** Do not proceed. Immediately introduce further controls. Detailed action plan required. Color code red.
    b. **High (H) - Unsupportable risk:** Review and introduce additional controls. Requires senior management attention. Color code orange.
    c. **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.
    d. **Low (L) - Supportable risk:** Monitor and maintain controls in place. Manage by routine. Procedures. Little or no impact. Color code green.

Protective Measures

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

Examples:

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

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

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.

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, visual alarms, audible alarms, and so forth.

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.

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.

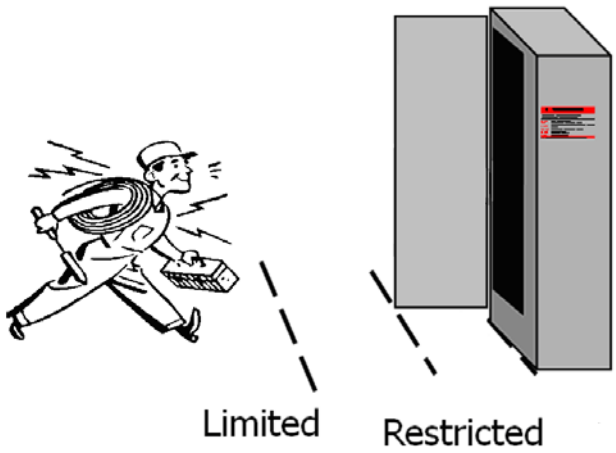
Personal Protective Equipment (PPE): The electrical system must be analyzed in order to determine the appropriate PPE. Once the appropriate PPE has been determined, personnel must maintain and use it as required in order to ensure that residual risk remains at the desired level. PPE is the last line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

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.

	Limited Approach Boundary		
Nominal System Voltage Range, Phase to Phase	**Exposed Movable Conductor**	**Exposed Fixed Circuit Part**	**Restricted Approach Boundary;** 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.:	
Planned **start** date/time:		Planned **end** date/time:	
Description of the work to be performed:			
Equipment requested to be shut down: (specify how long)			
	☐Until work is complete ☐Temporarily, while barriers are being placed		
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- Restricted approach boundary- NFPA 70E 130.4	_____ft. _____in. _____ft. _____in. ☐ Work will be conducted within this boundary.	
Results of the arc flash hazard analysis - NFPA 70E 130.7 (C)(15)(A)&(B)	☐ Determined from table in Appendix 10. _____ft._____in. ☐Calculation results: _____ft. _____in.	
PPE category for the task: ATPV rating (in cal/cm^2) for arc-rated clothing:	☐1 ☐2 ☐3 ☐4 (from Table 130.7(C)(15)(A) & (B)) ☐N/A ☐4 (Cat 1) ☐8 (Cat 2) ☐25 (Cat 3) ☐40 (Cat 4)	
☐Voltage-rated tools ☐Voltage-rated gloves ☐Safety glasses ☐Hearing protection ☐Leather gloves ☐Leather work shoes ☐Hard hat ☐Hard hat liner – arc-rated	☐Shirt, short sleeve (natural fiber) ☐Shirt, long sleeve (natural fiber) ☐Long pants (natural fiber) ☐Shirt, long-sleeve- 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
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?	Electrically Qualified Person(s)	Date

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:	Electrically Qualified Person:	Date:
Proposed Energized Electrical Work Review		
Proposed energized electrical work has been reviewed by:	Supervisor:	Date:
	Director of Trades or Facilities:	Date:
	EHRS:	Date:

APPENDIX 4 - JOB BRIEFING PLANNING CHECKLIST

Identify	
☐ The hazards	☐ How many people are needed to safely do the job?
☐ The voltage levels involved	☐ The shock protection boundaries
☐ Skills required	☐ The available incident energy
☐ Any "foreign" (secondary source) voltage source	☐ Potential for arc flash (Conduct a flash-hazard analysis)
☐ Any unusual work conditions	☐ The flash protection boundaries
Ask	
☐ Can the equipment be de-energized?	☐ Is a standby person required?
☐ Can the circuits to be worked on be back fed?	
Check	
☐ Job plans	☐ Safety procedures
☐ Single-line diagrams and vendor prints	☐ Vendor information
☐ Status board	☐ That individuals are familiar with the facility
☐ Facility and vendor resource information is up to date	
Know	
☐ What the job is	☐ Who is in charge?
☐ Who else needs to know – communicate!	
Think	
☐ About the unexpected event…what if?	☐ Install and remove grounds
☐ Lock-Tag-Test-Try	☐ Install barriers and barricades
☐ Test for voltage – FIRST	☐ What else….?
☐ Use the right tools and equipment, including PPE	
Prepare for an emergency	
☐ Is the standby person CPR trained?	☐ What is the exact work location?
☐ Is the required emergency equipment available?	☐ How is the equipment shut off in an emergency?
☐ Where is the nearest telephone?	☐ Where is the fire extinguisher?
☐ Where is the fire alarm?	☐ Are radio/cell phone communications available?
☐ Is confined space rescue available?	

APPENDIX 5 - TRAINING LOG

	Project/Work Order Number:		
	Company:		
	Date:		
	Trainer: (Printed) & Signature:		
	Trainees:		
	Name (Printed)	**Penn ID**	**Signature**
1			
2			
3			
4			
5			
6			
7			
8			
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11			
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APPENDIX 6 - HOW TO READ ARC FLASH LABELS

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

Shock Protection
Indicates the voltage level when "exposed energized parts" are present.
Limited Approach Boundary indicates the closest distance Unqualified Persons may approach.
Restricted Approach Boundary indicates when rubber gloves must be worn.
Prohibited Approach Boundary is the same as working on (removed in the NFPA 70E-2015 version).

Flash Protection
Indicates the Arc Flash PPE requirements by providing the Arc Flash PPE category or Hazard/Risk Category (HRC).
The incident energy level is the amount of energy available at the working distance. Wear arc rated PPE to at least this calorie rating when within the Flash Protection Boundary.
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 7 - ADDITIONAL SAFE WORK RULE DESCRIPTIONS

1. **Positively ensure the correct circuit is identified before lockout and tagout:** Every week an electrician is 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.

2. **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)

3. **The employee in charge must conduct a 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)

4. **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.

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

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

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

8. **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.

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

10. **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.

11. **Know Penn's 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. 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.

12. **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.

13. **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.

14. **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 Flash Protection Boundary to limit access area to Qualified Personnel only. This must be accomplished by using Energize Area signs and caution tape.

15. **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.

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

17. **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.

18. **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 8 - ELECTRICAL SAFETY AUDIT CHECKLIST

Location: _____

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 9 - ACCIDENT/INCIDENT REPORT

All injuries must be reported immediately**. Supervisors must complete this incident report and submit it through their Management to EHRS within two business days.**

TYPE INFORMATION BELOW

EMPLOYEE INFORMATION:					
Date of Accident or Incident:		**Time:**		**Date Reported:**	
Employee Name:					
PENN ID		**Department:**			
Job Title:		**Supervisor:**			
Witnesses:					

NATURE OF ACCIDENT OR INCIDENT:					
Accident or Incident result in:	**Injury**		**Illness**		**Near Miss**
	No Injury or Illness		**Lost Time**		**No Lost Time**
Location (Building & Room No:					
Nature and Location of Injury (burn to left hand, fracture to left ankle):					
Did Employee (s) receive medical evaluation?		**Yes**		**No**	
Where:		**When:**			

Description of Accident or Incident:	
List PPE in use:	

EMPLOYEE INFORMATION:
DESCRIBE ANY DAMAGE TO EQUIPMENT:

ANALYSIS:
Describe Hazard(s), Unsafe Condition(s) or Act(s):
PREVENTIVE ACTIONS:
Recommended Preventive Action(s):
Actions(s) & Date Taken:

Supervisor Signature:	**Date:**
Manager Signature:	**Date:**
Director Signature:	**Date:**
EHRS Signature:	**Date:**

APPENDIX 10 - 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:** The equipment is properly installed The equipment is properly maintained All equipment doors are closed and secured All equipment covers are in place and secured There is no evidence of impending failure	No
	One or more of the following: The equipment is not properly installed The equipment is not properly maintained Equipment doors are open or not secured Equipment covers are off or not secured 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:** The equipment is properly installed The equipment is properly maintained Covers for all other equipment are in place and secured There is no evidence of impending failure	No
	One or more of the following: The equipment is not properly installed The equipment is not properly maintained Equipment doors are open or not secured Equipment covers are off or not secured There is evidence of impending failure	Yes
Removal or installation of CBs or switches	Any	Yes

APPENDIX 10 - ARC FLASH HAZARD IDENTIFICATION FOR AC and DC SYSTEMS (cont.)		
Task	**Equipment Condition***	**Arc Flash PPE Required?**
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:** The equipment is properly installed The equipment is properly maintained There is no evidence of impending failure	No
	Any of the following: The equipment is not properly installed The equipment is not properly maintained 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:** The equipment is properly installed The equipment is properly maintained Covers for all other equipment are in place and secured There is no evidence of impending failure	No
	One or more of the following: The equipment is not properly installed The equipment is not properly maintained Equipment doors are open or not secured Equipment covers are off or not secured 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

APPENDIX 10 - ARC FLASH HAZARD IDENTIFICATION FOR AC and DC SYSTEMS (cont.)		
Task	**Equipment Condition***	**Arc Flash PPE Required?**
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

APPENDIX 10 - ARC FLASH HAZARD IDENTIFICATION FOR AC and DC SYSTEMS (cont.)		
Task	**Condition***	**Arc Flash PPE Required?**
Arc-resistant switchgear Type 1 or 2 (for clearing times of <0.5 sec with a prospective fault current not to exceed the arc-resistant rating of the equipment) and metal enclosed interrupter switchgear, fused or unfused of arc resistant type construction, tested in accordance with IEEE C37.20.7: • Insertion or removal (racking) of CBs from cubicles • Insertion or removal (racking) of ground and test device • Insertion or removal (racking) of voltage transformers on or off the bus	**All of the following:** The equipment is properly installed The equipment is properly maintained All equipment doors are closed and secured All equipment covers are in place and secured There is no evidence of impending failure	No
	One or more of the following: The equipment is not properly installed The equipment is not properly maintained Equipment doors are open or not secured Equipment covers are off or not secured There is evidence of impending failure	Yes
Opening voltage transformer or control power transformer compartments	Any	Yes
Outdoor disconnect switch operation (hookstick 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 11 - ARC FLASH HAZARD PPE CATEGORIES 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.

ARC FLASH HAZARD PPE CATEGORIES FOR DC SYSTEMS

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 12 - HRC/ARC FLASH PERSONAL PROTECTIVE EQUIPMENT (PPE) CATEGORIES

HRC PPE Category 0: < 1.2 cal/cm^2
Clothing – Long sleeve shirt and long pants made of nonmelting or untreated natural fiber (i.e., untreated cotton) with a fabric weight of at least 4.5 oz./square yard.
PPE - safety glasses or safety goggles, hearing protection (ear canal inserts), voltage rated gloves with leather protectors.
HRC/Arc Flash PPE Category 1: Minimum Arc Rating of 4 cal/cm^2
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.
PPE – Class 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/cm^2
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.
PPE – Class 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/cm^2
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.
PPE – Class 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/cm^2).
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.
PPE – Class E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), leather footwear.

APPENDIX 13 - CUSTOM BUILT OR MODIFIED EQUIPMENT INSPECTION & APPROVAL FORM

Equipment Identification	

Equipment Name	
Equipment Fabricator	
Department	
Competent Person/Inspector	

Refer to Guidance Document for inspection criteria. Inspection Satisfactory: (Check Box)

1	Equipment examination	
2	Execution of work	
3	Exposed metal parts grounded	
4	Electrically conductive material likely to become energized is bonded	
5	Strength	
6	Electrical spacing	
7	Overcurrent protection appropriate for intended use	

NOTE: Approved equipment must be installed and used in accordance with the instructions provided by the designer/builder and the Inspector.

Comments: Include all designer/builder instructions, restrictions on use, drawings or information that is relevant to the safe installation and use of this equipment. Attach additional sheets as necessary.

Equipment status following review (indicate status);

- ☐ Approved
- ☐ Conditional Approval (as documented above)
- ☐ NRTL (for items approved by an NRTL)
- ☐ Rejected

Once approved for use, if this equipment is modified, relocated, damaged, repaired or utilized for other than the intended use stated above, this approval is void pending re-examination

Date:		
	Inspector - Print Name	Inspector - Signature