Penn EHRS
Environmental Health & Radiation Safety

University of Pennsylvania

Electrical Safety Program

Environmental Health & Radiation Safety
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1. PURPOSE & CORE PRINCIPLES

Electricity has long been recognized as a serious workplace hazard, exposing those who interact with it to such dangers as electric shock, electrocution, fires and explosions. The goal of Penn's Electrical Safety Program is to prevent electricity-related injuries and damage to equipment and facilities. This program also calls for the appropriate training for University of Pennsylvania (Penn) faculty, staff, and students to ensure they have the requisite knowledge and understanding of safe electrical work practices and procedures. Only those qualified in this program may conduct diagnostics, adjustments, repairs or replacement of electrical components or equipment at Penn.

The installation and maintenance of all electrical facilities shall prioritize safety. All work involving electrical energy shall be performed using the appropriate safe work practices. 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 to identify and mitigate the electrical hazards.** Identify steps that could create electric shock or arc flash hazards. De-energize the equipment or insulate or isolate exposed energized conductors or circuit parts so you cannot contact them.
- **Anticipate the unexpected**. Assume the worst will happen and take the appropriate measures to protect yourself from shock, burn, blast, and other hazards inherent to the work environment.
- **Inspect and evaluate the electrical equipment**. Identify potential issues with the equipment prior to working on it and verify voltage and other information on the equipment nameplates matches what is expected.
- **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 the 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 de-energizing introduces additional or increased hazards or infeasibility due to equipment design or operational limitations including testing of electric circuits that can only be performed with the circuit energized.

Justification for energized work must be provided and include 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 safely.
- Proper safety planning and preparation occurs.
- Proper personal protective equipment (PPE) is utilized.

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

2. SCOPE

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

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.

Arc Flash Hazard - A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

Arc Flash Risk Assessment - An overall process that identifies hazards, estimates the likelihood of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

Arc Rating - The value attributed to materials that describe 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.

Authority Having Jurisdiction (AHJ) - An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

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

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

Boundary, Arc Flash - When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

Boundary, Electrical Safety - The minimum distance Qualified Persons shall keep unqualified persons away. This boundary encompasses the Arc Flash Boundary for arc flash protection and the Limited Approach Boundary for shock protection.

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.

Clearance Distance - Shortest distance through the air between two conductive parts.

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.

Creepage Distance - Shortest distance along the surface of the insulating material between two conductive parts.

Critical Component(s) - Electrical components or assemblies used in a power control or safety circuit whose proper operation is essential to the safe performance of the equipment or an electrical system or circuit.

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 its 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 for isolating a circuit or equipment from a source of power.

Electrical Equipment - Any device, appliance, or machine that generates, conducts, stores, or uses electrical energy.

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

Electrical Safety – Identification of hazards associated with the use of electrical energy and the precautions taken to reduce the risk associated with those hazards.

Electrical Safety Authority (ESA) - The authority having jurisdiction (AHJ) for custom built or modified electrical equipment used in teaching and research laboratories. EHRS shall serve as the ESA at Penn and assist the laboratories through the Field Evaluation process that is required to help ensure that the equipment is safe for use.

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

Electrical 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.

Emergency Stop (Estop) - An emergency operation intended to switch off the supply of electrical energy to all or part of the equipment.

Electrical Shock Hazard - A source of possible injury or damage to health associated with current passing through the body caused by contact or approach to exposed energized electrical conductors or circuit parts.

Enclosed - Surrounded by a case, housing, fence, or wall(s) that prevents people from unintentionally contacting energized parts.

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

Energized - Electrically connected to, or 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 – An evaluation of non-listed or modified equipment in the field that is performed by persons or parties acceptable to the authority having jurisdiction.

Field Evaluation Body (FEB) - An organization, or part of an organization, that performs field evaluations of electrical or other equipment.

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: A Class-A GFCI trips when the ground fault current is 6 mA or higher and does not trip when the ground fault current 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 that is 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.

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

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.

Maintenance, Condition of - The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.

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 the hazards and avoid the associated risk.

Research and Development (R & D) – An activity in an installation specifically designated for research or development conducted with custom or special electrical equipment.

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

Safeguarding – Safeguards for personnel include the consistent administrative enforcement of safe work practices. Safeguards include training in safe work practices, cell line design, safety equipment, personal protective equipment, operating procedures, and work checklists.

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

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

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

Working Distance - The distance between a person's face and chest area and a prospective arc source.

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. Examples of "working on" can include but are not limited to *diagnostic testing* (such as taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts and *repair* or physical alteration of electrical equipment, conductors, or circuit parts (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, Faculty & 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, tapes, cones, etc.).

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

C) Students, Employees & Qualified Persons:

1) Understand the hazards and operation of the equipment being interacted with.

2) Be familiar with procedures for evaluating how the task will be performed, including the use of standard operating procedures, and all options for performing the task 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 appropriate faculty or 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, and in the case of multi-employer job sites, the General Contractor (GC), 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 to make the required assessments.

2) Penn shall report observed hazardous conditions or unsafe work practices of contract employer employees to the contract employer or the GC.

E) Outside Contractors

1) The contract employer shall ensure that each employee is notified of the hazards communicated to the contract employer by Penn.

2) The contract employer shall ensure that each employee follows the work practices required under Penn's safety-related work rules.

3) The contract employer shall follow Penn's Facilities and Real Estate Services Design Standards for building components and systems for renovation and new construction projects. With respect to electrical safety, Division 01 General and Division 26 Electrical are particularly relevant.

4) Must maintain the required documentation including permit-required confined space, hot work, documentation of job briefings and energized electrical work permits.

5) **Shall not perform any work on energized electrical equipment without prior notification and approval from Penn's Office of Environmental Health & Radiation Safety (EHRS) and Facilities and Real Estate Services (FRES) Electrical Operations Supervisor.**

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

7) The contract employer shall coordinate the activities outlined in Appendix 12 – Requirements for Penn Electrical Contractors with Penn's Facilities and Real Estate Services (FRES) Electrical Operations Supervisor.

8) The contract employer/GC shall advise Penn of the following:
   a) Any unique hazards presented by the contract employer's work.
   b) Hazards identified during work by the contract employer that were not communicated by Penn.

c) The measures taken by the contract employer/GC to correct any unsafe work practices or other hazardous conditions raised by Penn.

5. HAZARD CONTROL

A) Hazard Elimination

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

B) 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 them 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-feet of side clearance shall be maintained for all distribution panels.

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

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

C) 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 diagnostics and 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 shall follow established electrical safety and standard operating procedures.

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

6. RISK ASSESSMENT PROCEDURE

A risk assessment shall be completed to identify and review the electrical hazards, the associated foreseeable tasks, and the protective measures that are required to maintain a tolerable level of risk. This includes the following before work is started:

1) Identify the electrical hazards.

2) Assess the risk by identifying and analyzing the tasks to be performed.

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

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 one might be exposed, shall be put into an electrically safe work condition before working on or near them, unless work on energized components can be justified.

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

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

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

The procedure to be followed by the Qualified Person working on the circuits is as follows (Use 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) Release stored electrical energy.

5) Release or block stored mechanical energy.

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

7) Verification - Use an appropriately rated and calibrated portable test instrument to test each phase conductor or circuit part at each point of work 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.

   Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:
   a) Placement – Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard (i.e., hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the job planning.
   b) Capacity – Temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.
   c) Impedance – Temporary protective grounding equipment and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

C) **Process of Reenergizing Equipment**

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

3) Each person 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.

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

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

All Penn students, faculty and staff 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 to permit work on one circuit or piece of equipment.
   c) Normal Operation – Normal operation of electric equipment shall be permitted where all the following conditions are satisfied:
      (i) The equipment is properly installed.
      (ii) The equipment is properly maintained.
      (iii) The equipment is used in accordance with instructions included in the NRTL listing and labeling and in accordance with the manufacturer's instructions.
      (iv) All equipment doors are closed and secured.
      (v) All equipment covers are in place and secured.
      (vi) There is no evidence of impending failure.

B) Energized Electrical Work Permit (See Appendix 3)

1) When Required – When energized work is performed as permitted in accordance with the criteria listed above, an energized electrical work permit shall be required and documented under the following conditions:

   a) When energized electrical work will be performed within the restricted approach boundary.
   b) When the employee may interact with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

The work permit shall include the following items:

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

2) Description of the work to be performed.

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

4) The voltage to which personnel will be exposed.

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

6) Determination of electrical shock and arc flash protection boundaries.

7) The necessary PPE required to safely perform the assigned task.

8) A description of the safe work practices to be used.

9) Means used to restrict the access of Unqualified Persons from the work area. Typically, this will consist of demarcating the electrical safety boundary using Energized Area Signs and/or Caution Energized Area Tape.

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

11) 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 a panel to observe live equipment, etc. shall be permitted to be performed without an energized electrical work permit, provided appropriate training, safe work practices, and personal protective equipment is provided and used. While a formal permit is not required, the expectation is that the Qualified Person will perform the electrical tasks following all the safe work practices detailed above.

   Examples:
   a) Thermography, ultrasound, and visual inspection up to restricted approach boundary.

b) Access/egress with no electrical work up to restricted approach boundary.
c) General housekeeping and miscellaneous non-electrical tasks up to restricted approach boundary.

D) Job Safety Planning and Job Briefing

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

1) Job Safety Planning - The job safety plan shall be in accordance with the following:

a) Be completed by a qualified person.
b) Be documented.
c) Include the following information:
   i) A description of the job and the individual tasks.
   ii) Identification of the electrical hazards associated with each task.
   iii) A shock risk assessment for tasks involving a shock hazard.
   iv) An arc flash risk assessment for tasks involving an arc flash hazard.
   v) Work procedures involved, special precautions, and energy source controls.

2) Job Briefings

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

a) The person in charge shall conduct a Job Briefing and it shall cover the following subjects:
   (i) Hazards associated with the work.
   (ii) Work procedures involved.
   (iii) Special precautions.
   (iv) Energy source controls.
   (v) Personal protective equipment requirements.
   (vi) What to do/whom to contact in an emergency.

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

c) Extent of Briefings: A brief discussion shall be satisfactory if the work involved is routine and if the individuals involved, by virtue of training and experience, can reasonably be expected to recognize and avoid the hazards involved in the job. A more extensive discussion shall be conducted if:
   (i) The work is complicated or particularly hazardous.
   (ii) The persons involved cannot be expected to recognize and avoid the hazards involved in the job.

E) Recordkeeping

Records including Energized Electrical Work Permits and associated supporting documents such as the risk assessments and completed Job Planning and Briefing checklist and any safety audit documentation shall be

maintained by the group responsible for the work/audit for a period of at least one year for the purpose of program auditing.

F) Observers

1) During the time that work is being performed on any exposed conductors or exposed parts of equipment connected to energized systems, a Qualified Person must be in close proximity at each work location to:
   a) Act primarily as an observer for the purpose of preventing an accident.
   b) Render immediate assistance in the event of an accident.
   c) Ensure that Safe Work Practices (see Appendix 6) are followed while performing energized electrical work.

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 and documented, the individual at risk shall take the necessary steps to minimize or eliminate the risks and shall select, apply, and utilize the necessary personal protective equipment for the task(s) to help prevent injury from shock, arc flash and other hazards.

A) Electrical Shock Protection – individuals performing the task shall conduct and document an Electrical 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 severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body. Variables including wet or broken skin and creating a pathway for electricity to flow through the chest can increase the severity of effects from a given current. It is important to be aware of how little current can lead to shock hazards to personnel.

1) Effects of Electric Current in the human body:
   a) At 1 milliampere, a faint tingle is perceptible.
   b) At 5 milliamperes, a slight shock felt. May cause a strong involuntary reaction that can lead to other injuries.
   c) 6 - 30 milliamperes, painful shock and loss of muscular control. A person may not be able to voluntarily let go of the energized electrical conductor or circuit part.
   d) 50 - 150 milliamperes, extreme pain and respiratory arrest likely. Severe muscular contractions. Death is possible.
   e) 1 - 4.3 amperes, rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur. Death is likely.
   f) 10 amperes - cardiac arrest and severe burns occur. Death is probable.
   g) 15 amperes - the lowest overcurrent at which a typical fuse or circuit breaker opens a circuit.

2) Rubber Insulated Gloves - Rubber insulated gloves which are rated for the highest phase to phase or phase to ground (whichever requires higher voltage class glove) voltage shall be worn where there is danger of injury from electric shock (due to contact with energized electrical conductors or circuit parts).

Where insulating rubber gloves are used for electrical 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 an electrical 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 students, faculty and staff 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 shall be replaced and destroyed immediately.

Rubber Insulated Glove Categories:

Class & Glove Tag Color	Maximum AC Voltage	Maximum DC Voltage
Class 00 – Beige (Beige)	500 volts	750 volts
Class 0 - Red	1,000 volts	1,500 volts
Class 1 - White	7,500 volts	11,250 volts
Class 2 – Yellow (Yellow)	17,000 volts	25,500 volts
Class 3 - Green	26,500 volts	39,750 volts
Class 4 - Orange	36,000 volts	54,000 volts

3) Testing 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 characteristics of the overcurrent protective device and its fault clearing 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 8 or as defined by an Incident Energy Analysis.

D) Arc Flash PPE

One of the following methods shall be used for the selection of PPE. Either, but not both, methods shall be permitted to be used on the same piece of equipment.

1) **Incident Energy Analysis Method** – 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 working distance at which the incident energy was determined. Some electrical equipment that had an incident energy analysis completed will have a label that lists the incident energy and electrical shock protection information. An example label is shown in Appendix 5. Specific label design requirements are described in Penn's Facilities & Real Estate Services Design Standards – Division 26 Section 260553 – Electrical Identification.

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

      (i) Incident energy exposures equal to 1.2 cal/cm^2 up to 12 cal/cm^2:
      - Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy.
      - Long-sleeve shirt and pants or coverall or arc flash suit.
      - Arc-rated face shield and arc-rated balaclava or arc flash suit hood.
      - Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) as needed.
      - Heavy-duty leather gloves, arc-rated gloves, or rubber insulting gloves with leather protectors.
      - Class E or G hard hat.
      - Safety glasses or safety goggles.
      - Hearing protection consisting of ear canal inserts.
      - Leather footwear.

      (ii) Incident energy exposures greater than 12 cal/cm^2:
      - Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy
      - Long-sleeve shirt and pants or coverall or arc flash suit.
      - Arc-rated arc flash suit hood.
      - Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) as needed.
      - Heavy-duty leather gloves, arc-rated gloves, or rubber insulting gloves with leather protectors.
      - Class E or G hard hat.
      - Safety glasses or safety goggles.
      - Hearing protection consisting of ear canal inserts.
      - Leather footwear.

2) **Arc Flash PPE Categories Method** – If the equipment does not have an incident energy analysis label defining the Hazard Risk Category (HRC)/Arc Flash PPE Category, or list the calculated incident energy,

the requirement for PPE and the appropriate arc flash PPE category required for the task may be determined from consulting Appendices 8 and 9 of this program along with a thorough risk assessment. If the equipment parameters defined in Appendices 8 and 9 do not match the equipment exactly, additional risk assessment must be conducted by a Qualified Person to determine the appropriate PPE category. Once the category is determined, personal protective equipment shall be selected from the appropriate HRC/Arc Flash PPE Category listed below. (Also exhibited in Appendix 10).

Note: Appendix 10 and the Hazard Risk Categories/Arc Flash PPE Categories listed directly below only account for equipment where the maximum anticipated exposure level is 40 cal/cm^2. Penn employees shall not work on energized equipment where the maximum anticipated exposure level exceeds 40 cal/cm^2 (typically referred to as "Dangerous" by an Incident Energy Analysis/label).

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

(i) **HRC/Arc Flash PPE Category 1: Minimum Arc Rating of 4 cal/cm^2 (16.75 J/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 or G hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.
(ii) **HRC/Arc Flash PPE Category 2: Minimum Arc Rating of 8 cal/cm^2 (33.5 J/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 or G hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.
(iii) **HRC/Arc Flash PPE Category 3**: **Minimum Arc Rating of 25 cal/cm^2 (104.7 J/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 or G hard hat, safety glasses or safety goggles, hearing protection, (ear canal inserts), leather footwear.
(iv) **HRC/Arc Flash PPE Category 4 Minimum Arc Rating of 40 cal/cm^2 (167.5 J/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 or G 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 required 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 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, clean, and reliable condition. PPE shall be inspected before each use. Should the PPE be out of certified date range (i.e., rubber insulating glove testing requirements), worn out, damaged, impaired or unsuitable for use or application, the worker has the responsibility to not use the PPE, tag the PPE with their name, a description of the problem and the date of the inspection and notify their supervisor. Work clothing or flash suits that are contaminated or damaged to the extent their protective qualities are impaired, shall not be used.

   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) Electrical installation work shall comply with Penn's Design Standards for building components and systems for renovation and new construction work.

B) 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 – AUTHORIZED PERSONNEL ONLY" or similar. Electrical safety signage should meet ANSI Z535 design standards.

2) Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures and motor control centers that are in other than dwelling units and that are likely to require examination,

adjustment or servicing, or maintenance while energized shall be marked with labels containing the following information:

a) Nominal system voltage.
b) Maximum available fault current. This must be amended as required to reflect modifications or changes to the installation over time.
c) List of who performed fault current calculations and date performed.
d) Available incident energy and the corresponding working distance, or the arc flash PPE category for the equipment but not both. Penn prefers to have the available incident energy and corresponding working distance information on labels.
e) Listing of who performed the incident energy analysis and date performed.
f) Arc flash boundary value.
g) Electrical shock protection limited and restricted approach boundary values.

C) 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.

D) 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 per building code at the time of installation.

E) 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) that is in effect at the time of installation per local building code and applicable ASTM, NEMA and OSHA standards and shall be UL listed for the application.

F) 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 NRTL listing or labeling for that identified purpose.

c) Mechanical strength and durability, including 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.

G) 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, cord and plug-connected tools used for construction and maintenance activities or used outdoors or in potentially damp or wet locations supplied by 125-volt, 15, 20 or 30-ampere circuits. GFCI protection devices shall be tested in accordance with the manufacturer's instructions.

2) In general, all equipment and tools connected by cord and plug must be grounded. NRTL 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, run through holes in walls, ceilings, or floors, run through doorways, windows, or similar openings, 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 or labeled by a NRTL. 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.

16) Adapters that interrupt the continuity of the equipment grounding conductor shall not be used.

H) 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

I) Guarding of Energized Parts

Energized parts of electrical equipment operating at 50 volts or more must be guarded against unintentional 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 in an area where it is potentially exposed to physical damage, the enclosure or guard must be of sufficient strength to prevent such damage.

J) 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.

K) Test Equipment and Instruments

1) Only Qualified Persons shall perform tasks such as testing, troubleshooting and voltage measuring on electrical equipment operating at voltage equal to or greater than 50 volts. 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) Electrical test equipment used by Penn students, faculty and staff 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.

L) 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.

M) 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** – Staff required to work in confined or enclosed spaces that contains exposed energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists, 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, and metal frame glasses) or items such as key rings 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.

N) 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. Electrical safety signs and labels should meet ANSI Z-535 design standards.

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. The Arc Flash Protection Boundary shall be demarcated by using Energized Area Signs and/or Caution Energized Area Tape.

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: Use an attendant while the Qualified Person is temporarily exposed to energized parts.

O) 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.

An important concept to understand is that NRTL listed/labeled electrical equipment has undergone rigorous testing to help ensure that it is safe for use. If electrical equipment is modified or custom built in-house, the laboratory/group responsible for modifying or building the equipment is responsible for the completion of a field evaluation of the equipment to ensure that it is safe for use. EHRS is available to provide guidance and identify resources to aid in completion of the field evaluation, however, EHRS cannot perform the field evaluation.

A) General

1) Equipment and installations that bear the seal of a NRTL are considered approved if 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 based on test data which the employer keeps and makes available for inspection.

3) EHRS or the laboratory Competent Person shall act as the Electrical Safety Authority (ESA) for Penn. In this role, EHRS will help guide the laboratory through the requirements of this section and if needed, assist with identifying the appropriate subject matter experts that may be needed to help the lab/group complete the field evaluation. EHRS shall not be responsible for field evaluation of equipment. The field evaluation must be completed by the Competent Person designated by the laboratory that modifies or builds the equipment. In some cases, the Competent Person may need to collaborate with the appropriate subject matter experts to assist with the field evaluation, but ultimately, the Competent Person must take responsibility for the equipment and ensure that it is safe for use.

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

5) A Competent Person is a 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.

   a) The Competent Person shall understand the following concepts:
      (i) Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment.
      (ii) Skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts.
      (iii) Approach distances specified in Appendix 2 and the corresponding voltages to which the individual will be exposed.
      (iv) Decision-making process necessary to be able to do the following:
         (a) Perform the job safety planning.
         (b) Identify electrical hazards.
         (c) Assess the associated risk.
         (d) Select the appropriate risk control methods from the hierarchy of controls including selection of appropriate personal protective equipment.

6) Where electrical equipment must be custom fabricated because NRTL 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 Custom Electrical Equipment Field Evaluation Form included in Appendix 11. The completed form shall be submitted to EHRS for attachment to the laboratory's BioRAFT record.

B) Energy Thresholds – Energy exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented as approved by the Competent Person:

1) AC: 50-volts and 5 milliamperes.

2) DC: 100-volts and 40 milliamperes.

3) Capacitive Systems:
   a) 100-volts and 100 Joules of stored energy
   b) 400-volts and 1.0 Joules of stored energy
   c) 0.25 Joules of stored energy

C) 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 NRTL 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.

D) Equipment Marking and Documentation:

1) Marking - Marking of equipment shall be required for, but not limited to, equipment fabricated, designed, or developed for research testing and evaluation of electrical systems. Marking shall sufficiently list all voltage entering or leaving control cabinets, enclosures, and equipment. Caution, Warning, or Danger labels shall be affixed to the exterior describing specific hazards and safety concerns. Refer to ANSI Z535, Series of Standards of Safety Signs and Tags for more information.

2) Documentation - Sufficient documentation shall be provided and readily available to personnel that install, operate, and maintain equipment that describes operation, shutdown, safety concerns and nonstandard installations. Schematics, drawings, and bill of materials describing power feeds, voltage, currents, and parts used for construction, maintenance and operation of the equipment shall be provided.

3) Shutdown Procedures - Safety requirements and emergency shutdown procedures of equipment shall include control of hazardous energy (lockout/tagout) requirements.

4) Approvals - Drawings, standard operating procedures and equipment shall be approved by the Competent Person. Assembly of equipment shall comply with national standards where applicable unless research application requires exceptions. Equipment that does not carry a listing or label from a NRTL shall be Field Evaluated. Proper safety shutdown procedures and PPE requirements shall be considered in the absence of grounding and/or bonding.

E) Field Evaluation Process

1) The laboratory or entity responsible for modification or custom fabrication of electrical equipment must complete or arrange for field evaluation of the equipment. The equipment must be inspected and approved by a Competent Person and documented on the Custom Electrical Equipment Field Evaluation Form (Appendix 11). The completed form must be submitted to the ESA and/or (EHRS) for review prior to start-up. The ESA will review the form and contact the lab if concerns are identified or upload the form to the lab's BioRAFT record. After review and approval, an "Electrical Safety Approved" barcode label will be supplied by EHRS to the Competent Person to install on the equipment. Once the completed form is uploaded to BioRAFT and the approval label is installed on the equipment, it may be considered approved for use.

2) **Documentation:** The following documents must be maintained by the laboratory that modified or fabricated the electrical equipment. This information is used by the Field Evaluation Body for the equipment evaluation:
   a) Justification for in-house modifications of NRTL listed or labeled equipment or need for in-house fabrication of equipment.
   b) Layout drawing showing all equipment with designators that match the schematic and actual marks on, or adjacent to the equipment.
   c) Electrical schematic drawings for all power, control, and safety circuits.
   d) A bill of material that includes certification details for all critical components.
   e) Limitations or conditions of acceptability for critical components.
   f) Installation, operation, and maintenance manuals for the equipment to be installed.
   g) Qualifications of the fabricator. Qualifications include adequate technical electrical/electronic and electrical safety knowledge.
   h) Completed Custom Electrical Equipment Field Evaluation Form (Appendix 11). The form must be maintained for the life of the equipment.

3) **Standard(s)**: The Field Evaluation Body (FEB) should select nationally recognized standards applicable to the subject equipment under evaluation based on the equipment's design and application. Where no single standard applies to the equipment, applicable portions of related standards for subassemblies and supplementary standards should be applied.
   a) Primary Standard - The primary standard to be used should be a nationally recognized safety standard written and maintained by a standards development organization that issues safety standards.
   b) Jurisdictional Notification - The FEB should notify the electrical AHJ (EHRS) when an evaluation is initiated and about to commence.

4) **Construction Inspection:** This section provides typical construction requirements that should be considered in the field evaluation. The actual requirements to be used for the construction inspection should come from the applicable primary product safety standard and electrical installation codes.
   a) Electrical Code Considerations - Ensuring that the product can be installed in accordance with the electrical code should include but is not limited to the verification of the following:
      (i) Presence of complete equipment nameplate(s)
      (ii) Equipment construction provides for code-compliant installation.
      (iii) Installation instructions include sufficient detail (showing raceway entry points, supply conductor wiring methods, supply conductor types, field wiring torque values, and installer supplied overcurrent protection)
      (iv) Adequate wire bending space for all field wiring terminals.

b) Construction of Enclosures - Enclosure inspection should include but not be limited to the following:
   (i) Suitable use of metallic and nonmetallic construction materials.
   (ii) Enclosure-type rating (e.g., 1, 3R, 4X) suitable for the intended application or installation environment.
   (iii) Methods of corrosion protection for internal and external parts.
   (iv) Methods of fastening doors and covers.
   (v) Hinged doors open at least 90 degrees.
   (vi) Bonding methods of dead metal parts likely to become energized.
   (vii) Accessibility of live parts.
c) Disconnecting Means - The means to disconnect equipment should be reviewed for suitability and compliance with installation codes.
d) Main Overcurrent Protection Device (OCPD) - Main overcurrent protection supplied by the manufacturer or field installed should be verified as suitable for the loads involved, voltage, and interrupting rating.
e) Field Terminations - Field wiring terminals should be identified.
f) Components - The verification of equipment components should include, but not be limited to the following:
   (i) Accuracy of and correlation between component identifications in drawings, the bill of material, and marking within equipment.
   (ii) Critical components listed or recognized and labeled by a nationally recognized testing laboratory (NRTL).
   (iii) Critical Components used in accordance with their listing, or the "conditions of acceptability" defined by an NRTL.
   (iv) Suitability of mounting methods.
   (v) Suitability of components to perform as intended considering the critical/safety function of the device, mechanical and electrical loads, and other factors affecting the immediate environment or performance of the component.
g) Overcurrent Protection - Overcurrent inspections should consider suitability of applications that include but are not limited to the following:
   (i) Overcurrent protection of conductors per the conductor ampacity.
   (ii) Power supply overcurrent protection.
   (iii) Transformer overcurrent protection for power and control.
   (iv) Motor overcurrent protection, including short circuit, ground fault, and overload protection, provided, and properly rated.
   (v) Maintenance receptacle overcurrent protection.
   (vi) Heater load overcurrent protection
   (vii) Plug strips and portable power taps overcurrent protection.
   (viii) Overcurrent protection for control circuits and control circuit devices.
h) Wiring - Wiring should be inspected for the following:
   (i) Correct color code or other identification used.
   (ii) Insulation types rated for the application and intended environment.
   (iii) Conductor temperature ratings adequate.
   (iv) Ampacity for load served and overcurrent protection provided.
   (v) Flame rating of VW-1 or equivalent insulation.
   (vi) Correct use of flexible cords.
   (vii) Correct use and physical protection of flexible cables.
   (viii) Separation of low voltage, Class 2 or Class 3 conductors from power conductors.
i) Markings - Markings should be inspected for the following:

(i) Access warnings for shock hazard.
(ii) Multiple source warnings.
(iii) Environmental restrictions such as "Indoor Use Only"
(iv) Field wiring type such as "Copper Conductors Only"
(v) Component designations that match the layout and schematic drawings.
(vi) Control device functional identification.
(vii) Equipment grounding terminal marking.
(viii) Fuse replacement markings or chart.
(ix) Replacement elements and ratings for overload relays provided with changeable elements.

j) Grounding - Grounding/bonding provisions should be inspected for the following:
(i) Provision for terminating the supply equipment grounding conductor.
(ii) One conductor per terminal for all equipment grounding conductors in ground fault paths.
(iii) Equipment grounding conductors identified by color coding (green or green with one or more yellow stripes) or by other suitable markings.
(iv) All conductive enclosure doors and panels are correctly bonded.

k) Distances Between Exposed Energized Parts - Distances between exposed energized parts should be inspected for adequate creepage distance and clearance distance for the voltage provided.

5) **Electrical Testing:** The electrical testing program should follow the applicable standards as closely as practical, considering the limits of a nonlaboratory setting and the need for the equipment to perform all required functions after the test. The following typical tests and measurements on complete units or subassemblies should be completed as specified in the applicable standard:
a) Insulation resistance test on power circuit with all sensitive electronic components such as line filters and Rf filters disconnected.
b) Ground continuity of bonded parts to supply equipment grounding conductor termination point.
c) Measurement of the input voltage while under maximum design load.
d) Measurement of the input full load current while at the maximum design load normal operation.
e) Temperature rise testing of terminals and heat producing devices (transformers, power supplies, coils, heaters) and components that could be affected by an elevated ambient temperature caused by other heat producing components.
f) Safety interlock circuit function testing.
g) Emergency stop.
h) Electrical Tests - The following electrical tests should be completed as required by the applicable product standard where identified as production or routine tests:
(i) Leakage current on cord-and-plug-connected equipment.
(ii) Dielectric withstand (hipot) on power circuits.
(iii) Other production tests.

6) **Reporting and Documentation -** Each evaluation should result in a complete report detailing the results of the evaluation and a statement of conformity made from the results.
a) Discrepancies and Nonconformities - Discrepancies and nonconformities that must be resolved to comply with requirements should be promptly brought to the attention of the appropriate parties.
(i) Where successful correction of nonconformance occurs, the report should include details of the corrective action.
(ii) Discrepancies and nonconformities brought to the builder's attention should also be brought to the attention of EHRS.
(iii) A copy of the report including the Custom Electric Field Evaluation Form shall be submitted to EHRS.

(iv) Conditions of Acceptability – A statement or series of statements establish specific conditions of acceptability to be adhered to in order to maintain the label as valid should be included.

b) Standards - The complete citation of the primary and any contributing support standards used to complete the evaluations should be included.
   (i) The citation should be complete so that any subsequent audit can clearly identify the exact edition and revision of the standard(s) used.

c) Equipment Identification and Nameplate – The equipment nameplate information should be documented for each manufactured piece of equipment that was evaluated as follows:
   (i) Designation of equipment
   (ii) Manufacturer
   (iii) Model identification
   (iv) Serial number
   (v) Electrical ratings
   (vi) Mechanical ratings as applicable
   (vii) FEB label Serial Number

d) Evaluation procedures – The detailed procedures used to inspect, test, and evaluate the product should be documented.
   (i) The evaluation procedures should be separated in the major category areas as detailed in sections 5 and 6 with sufficient explanation for clear understanding to all parties involved, including the builder, EHRS and the end user.
   (ii) The evaluation section should include the following:
      (a) A brief product description of the equipment's function and its intended operation.
      (b) Construction evaluation results found acceptable.
      (c) Electrical testing results found acceptable.
      (d) Discrepancies for each item found nonconforming, including a description of the nonconformance, an explanation of the hazards, the standards citation, the remedial action to resolve the nonconformance, and the final resolution.
      (e) Test instrumentation calibration information.
   (iii) Appendices or Attachments – The following details should be included as appendices or attachments to the report:
      (a) Reference drawings used for the evaluation.
      (b) Data sheet(s) documenting the test results from each of the electrical tests.
      (c) The bill of material (critical components list).
      (d) Photographs of the discrepancies found, the resolution, and the overall equipment.
      (e) Field notes, checklists, or other supporting data that would benefit the end user.

7) **Field Evaluation Label** – After all identified issues have been fully resolved, all electrical testing has been satisfactorily completed, and the evaluation has determined that the equipment meets the applicable requirements of the standard(s), a label shall be affixed to the equipment.

a) Label Contents
   (i) The label shall state Penn EHRS - "Electrical Safety Approved".
   (ii) The label shall contain a unique number and barcode.
   (iii) The label should have a means to identify if the equipment has more than one major assembly and therefore has more than one serialized label applied.

b) Label Location
   (i) The evaluation label should be installed near the equipment nameplate.
   (ii) The label must be durable enough to withstand the expected use environment. Default label is metal foil.

c) Label Control
   (i) The label shall be applied exclusively by the FEB.
   (ii) EHRS shall supply the label to the FEB upon request for installation.
   (iii) In no case shall a label be applied to a product that has not been evaluated by the FEB.
   (iv) The evaluator should enter the label serial number(s) into the field data work sheets.
   (v) The label information should be recorded in the report. EHRS will enter the label number and equipment data information in our Custom Electrical Equipment database.

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 must grant approval to complete the work.

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 listed Ground Fault Circuit Interrupter (GFCIs) protective devices;
   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 contact the 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) Always observe proper polarity connections.

9) Always ensure unobstructed egress from the battery area when testing.

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

11) In battery charging areas where ventilation is not continuous, a hydrogen sensing system must be installed that emits an alarm and can start the ventilation system while the hydrogen concentration is well below the lower explosive limit.

12) Flame arresters should be installed on all batteries.

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

14) 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.

15) 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. Always keep the top of the battery clear of tools and other foreign objects. Battery terminals and connections should be protected by rubber boots or a non-conductive cover to prevent accidental arcing across the terminals.

16) 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.

17) Cells connected in series likely have high voltages that could present a shock hazard.

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

19) Those handling batteries may accumulate static charge, especially on dry days. Always touch a grounded surface to discharge static before touching a cell post.

20) Transporting Batteries:
   a) Use proper materials handling and lifting techniques. EHRS can provide specific training.
   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.

21) Visually check to ensure metal battery racks are properly connected to the station ground.

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

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

24) 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 a sudden reaction to electrical shock or other causes.

2) Portable ladders shall have non-conductive side-rails if they are used where the person or the ladder could contact exposed energized parts. Metal ladders are not permitted. All ladders shall be labeled indicating they meet the applicable ANSI A14 ladder safety 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 Penn's Mobile 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 warmup 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 bucket 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) Operator 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 handline may be attached to raise and lower protective equipment, hand tools and light material. The handline 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 despite 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:
Always verify that communications can be quickly established from the job site (i.e., cell phone signal or working landline nearby).

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 at HUP - 3400 Spruce Street, Ravdin Second Floor. After these hours, seek treatment at HUP Emergency Medicine located at the Hospital Pavilion at 1 Civic Center Boulevard.

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.

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 the closest Emergency Department.

14. TRAINING

A) Technical Training

1) Faculty and Supervisors are responsible for identifying and coordinating specialized technical training required for their students or employees. Contact EHRS if assistance is needed to identify training resources.

2) One who is undergoing on-the-job training and who, during 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.

3) For an individual to be qualified on a specific activity, he/she must be trained on that work activity or provide documentation that demonstrates the individual's ability to safely perform the work activity.

B) Electrical Safety Training

1) To identify and understand the relationship between electrical hazards and possible injury, faculty, staff and students exposed to electrical hazards when the risk associated with that hazard is not reduced to a

safe level by the applicable electrical installation requirements, shall be trained in safety-related work practices and procedural requirements related to the task or curriculum. Contact EHRS if assistance is needed to define the scope of training and identify available resources. The curriculum for electrical safety training presented to students must be reviewed and approved by EHRS. Training of faculty and staff shall be documented and entered in Penn's learning management system by EHRS. Documentation of student training shall be maintained by the faculty or staff member responsible for the curriculum or project requiring interaction with electricity.

2) All Qualified Persons must be trained in Penn's Electrical Safety Program and NFPA 70E 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) Contact Release: Those exposed to shock hazards and/or responsible for the safe release of victims from contact with energized electrical conductors or circuit parts shall be trained in methods of safe release. This training shall occur annually.

5) Control of Hazardous Energy (Lockout/Tagout) procedures which are used to place electrical equipment into a safe work condition requires specific training which is covered in Penn's Control of Hazardous Energy (Lockout/Tagout) Program.

C) 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) Electrical Safety Program Audit

Penn's 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.

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 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.

B) Field Work Audit

Field work shall be audited to verify that the requirements contained in this program are being followed. When the auditing determines that the principals and procedures of the electrical safety program are not being followed, the appropriate revisions to the training program or revisions to the procedures shall be made. Audits shall be performed at intervals not to exceed one year. The Electrical Safety Audit Checklist may be used to assist with this process. (Appendix 7)

16. OTHER ITEMS

A) Accidents and Near Misses

Accidents and Near Misses must be documented using the appropriate Penn Incident Report Form. https://ehrs.upenn.edu/health-safety/incident-reporting-forms

Information that should be documented includes the following:

1) Individuals involved. List names of all individuals 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 required to safely perform the assigned task and details of its use.

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 Equipment"

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, 2024 Edition

G) National Fire Protection Association (NFPA) NFPA 791 – Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation

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

I) University of Pennsylvania Electrical Safety Fact Sheet

J) University of Pennsylvania Materials Handling and Lifting Fact Sheet

K) University of Pennsylvania Mobile Elevating Work Platform Program

L) University of Pennsylvania Confined Space Programs

M) City of Philadelphia Fire Code

APPENDIX 1 - RISK ASSESSMENT PROCESS

This appendix provides details on how to perform a risk assessment, which includes a review of the electrical hazards, the associated foreseeable tasks, and the protective measures that are required 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: electrical 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 personal protective equipment, 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.

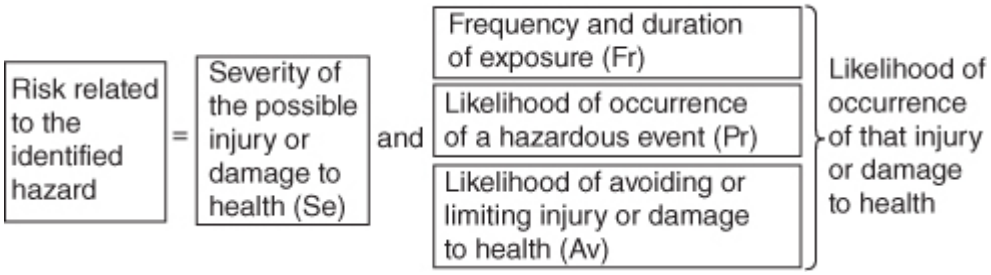


Figure 1 Elements of Risk

Risk Assessment Calculation

The 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.

Example 1 - 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)
< or = 1 per hour	5
> 1 per hour to ≤ 1 per day	5
> 1 per day to < or = 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 event 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 the 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 considering the following factors:
    a. The predictability of the performance of component parts of the electrical system relevant to the hazard in different modes of use (e.g., normal operation, maintenance, fault finding).

At this point in the risk assessment process, the protective effect of any personal protective equipment (PPE) and other protective measures should not be considered. This is necessary 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 regarding 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 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 considering aspects of the electrical system design and its intended application that can help to avoid or limit the injury or damage to health from a hazard, including the following examples:
    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 near 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 its appearance, whether it is under voltage or not. To recognize the presence of the hazard, an instrument is needed to establish whether or not the 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 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.

Example 2 - 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 personal protective equipment 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 the 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 regarding risk reduction. They should be chosen based on the design configuration for each specific application and their potential effectiveness during the foreseen interaction. Each design and configuration can require unique awareness devices to have the desired impact on risk. Typically, awareness means take the form of signs and visual and audible alarms.

Administrative Controls (Procedures): Procedures and instructions that are required for individuals to safely interact with the electrical system should be identified. The procedures and instructions 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, regarding 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 can 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 where only awareness of electrical hazards is needed to ensure that unqualified personnel do not interact with the electrical system.

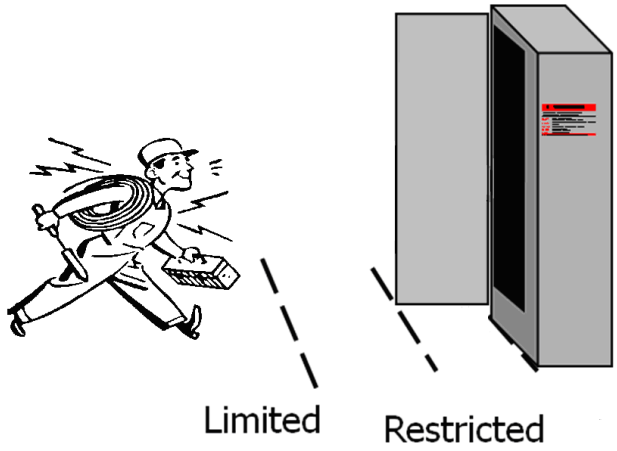
Personal Protective Equipment (PPE): The electrical system must be analyzed to determine the appropriate PPE. Once the appropriate PPE has been determined, personnel must maintain and use it as required to ensure that residual risk remains at the desired level. PPE is the last line of defense.

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

APPENDIX 2 – ELECTRICAL 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

ELECTRICAL SAFETY JOB PLANNING & BRIEFING 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?	

ELECTRICAL SAFETY JOB PLANNING & BRIEFING CHECKLIST (Page 2)

COMPLETED BY: _____DATE:_____
TASK/LOCATION: _____
ATTENDEES

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Notes:

APPENDIX 5 - HOW TO READ INCIDENT ENERGY/ARC FLASH LABELS

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

Shock Protection

- Nominal system voltage when "exposed energized parts" are present is listed.
- Limited Approach Boundary indicates the closest distance Unqualified Persons may approach.
- Restricted Approach Boundary indicates when rubber gloves must be worn.

Flash Protection

- The Arc Flash PPE requirements are defined either by providing the Arc Flash PPE/HRC category/OR the incident energy level. The label should not contain both the incident energy value AND PPE category because it can lead to confusion.
- The incident energy is the amount of energy available at the working distance. Wear arc rated PPE rated at minimum with this calorie rating when within the Flash Protection Boundary.
- The Flash Protection Boundary is the distance from the source that a person could receive a second degree burn if a flash occurred. All parts of your body within this boundary must be protected from a flash.

APPENDIX 6 - ADDITIONAL SAFE WORK PRACTICE DESCRIPTIONS

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

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

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 (verified deenergized), 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, keyrings 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. Verify

communication means to summon outside help. Qualified Persons working on or observing work on energized transmission and distribution conductors and circuit parts shall maintain cardiopulmonary resuscitation (CPR) and First Aid certification.

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 Arc Flash Protection Boundary to limit access to Qualified Personnel only. This should be accomplished by using Energized Area Signs and/or Caution Energized Area 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 voltage rated gloves.

16. **Never modify or penetrate premises wiring conduit or enclosed wireways**: Only Qualified Personnel are allowed to work on premises 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 appropriate PPE and insulated tools.

18. **Turn off cell phones while working around energized equipment**: Like texting and driving don't mix; cell phones can't be a distraction while working around energized equipment.

APPENDIX 7 - ELECTRICAL SAFETY AUDIT CHECKLIST

Location: _____ Completed by: _____

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

APPENDIX 8 - ARC FLASH HAZARD IDENTIFICATION FOR AC and DC SYSTEMS

Task	Equipment Condition*	Arc Flash PPE Required?
Reading a panel meter while operating a meter switch	Any	No
Normal operation of a circuit breaker (CB), switch, contactor, or starter	**All of the following:** 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 8 - 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 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 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 8 - 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 8 - 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 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 9 - ARC FLASH HAZARD PPE REQUIREMENTS FOR AC and DC SYSTEMS

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

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

ARC FLASH HAZARD PPE REQUIREMENTS 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 10 - HRC/ARC FLASH PERSONAL PROTECTIVE EQUIPMENT (PPE) CATEGORIES

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 G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.
HRC/Arc Flash PPE Category 2: Minimum Arc Rating of 8 cal/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 G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), voltage-rated rubber gloves with heavy duty leather gloves, leather footwear.
HRC/Arc Flash PPE Category 3: Minimum Arc Rating of 25 cal/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 G or E hard hat, safety glasses or safety goggles, hearing protection, (ear canal inserts), leather footwear.
HRC/Arc Flash PPE Category 4: Minimum Arc Rating of 40 cal/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 G or E hard hat, safety glasses or safety goggles, hearing protection (ear canal inserts), leather footwear.

APPENDIX 11 - CUSTOM ELECTRICAL EQUIPMENT FIELD EVALUATION FORM

Equipment Identification (EHRS Approval Barcode #)	

Equipment Name	
Equipment Builder	
Department	
Competent Person/Inspector	

Refer to Penn's Electrical Safety Program for inspection criteria. Inspection Satisfactory: (Check Box)

1	Electrical code compliance	☐
2	Construction of enclosure(s)	☐
3	Disconnecting means	☐
4	Main overcurrent protection device	☐
5	Field terminations	☐
6	Components	☐
7	Overcurrent protection	☐
8	Wiring	☐
9	Markings	☐
10	Grounding	☐
11	Distances between exposed energized parts	☐
12	Electrical testing completed	☐
13	Reporting, documentation, and labeling	☐

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 pages as necessary.

Equipment status following review (indicate status);

☐ Approved – Competent Person/Inspector - Form uploaded by EHRS to BioRAFT
☐ Conditional Approval (as documented above)
☐ NRTL (for items approved by an NRTL)
☐ Rejected (Note reason here):

Date:		
	Inspector - Print Name	Inspector – Signature

Submit completed form to EHRS. EHRS will review and if acceptable, provide an approval bar code label.
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.

APPENDIX 12 - REQUIREMENTS FOR UPENN ELECTRICAL CONTRACTORS

All electrical contracting work shall be performed with the utmost attention to safety, in strict adherence to the applicable Penn, NFPA, and City of Philadelphia codes and standards. The goal is to ensure the safety of the workers, occupants and protection of the building and associated systems. The activities outlined in this document require coordination with the Facilities and Real Estate Services (FRES) Electrical Operations Supervisor.

1. **ANY ENERGIZED WORK** must receive prior approval from the University Electrical Supervisor/Electrical Operations Supervisor, Director of Trades, and EHRS. This is to ensure the highest standards of safety for both the contractors and the University community.

Examples of energized work (not limited to) that require approval:

- Installing conduit into an energized panel.
- Removing the panel cover from an energized panel.
- Knocking out a hole in an energized panel.
- Removing or installing a breaker in an energized panel.
- Any tool work that may come into contact with an energized wire, electrical bus work, or an electrical connection.
- Pulling wire into an energized panel.
- Fishing a conduit in an energized panel.

2. **ALL TEMPORARY ELECTRICAL PROVISIONS** for a project must be approved by FRES Engineering and/or Electrical Operations. These temporary installations must be executed in the safest manner possible to prevent any risks to building integrity or occupant safety. If temporary power is only serving the project area, the electrical contractor can operate the associated breakers with caution.

3. **IF AN ELECTRICAL PANEL** is located entirely within the space being renovated and has been verified to only affect that space, the electrical contractor may operate the branch circuits within the panel, ensuring no risk to areas beyond the project scope.

4. **DE-ENERGIZATION OF PANEL FEEDERS** must be coordinated with the Electrical Operations Supervisor and their staff.

5. **ANY WORK IN LOCAL PANELS** and distribution panels that serve areas outside of the project scope must be closely coordinated with the Electrical Operations Supervisor and their staff to prevent any unintended disruptions.

6. **ACCESS TO UNIVERSITY MAIN SUBSTATIONS** must be coordinated with the Electrical Operations Supervisor and their staff, ensuring these critical areas are handled with the highest safety standards.

ACCESS TO UNIVERSITY BUILDING SUBSTATIONS can be granted to the electrical contractor as an "Electrically Qualified Person." Key requests must be sent to the University Locksmith Shop as an AIM work request by the D&C Project Manager and will be subsequently approved by the Electrical Operations Supervisor, ensuring controlled and safe access.