Electrical Safety Program

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Chapter 1: Introduction

1.1 Purpose

The Electrical Safety Program (ESP) was created to comply with electrical systems regulatory requirements to ensure that energized electrical work at Purdue University facilities is performed safely by qualified electrical workers who are provided with appropriate safe work procedures, protective equipment, and other controls. It is intended to protect employees against electricity-related hazards. These hazards include electrical shock and burns; arc flash burns; arc-blast impacts; falls; and other potential electrical safety hazards. Working on equipment in a de-energized state is required unless de-energizing introduces an increased hazard or is infeasible (e.g., voltage testing to troubleshoot).

1.2 Scope

This program applies to all Purdue University facilities and work performed by its employees regardless of job site location. The Program has been established to ensure the safety of employees who may work on or near electrical equipment 600 volts or less. These employees must comply with 29 CFR 1910 Subpart S of the Occupational Safety and Health Administration (OSHA) and National Fire Protection Association (NFPA) 70E 2018 edition. Employees working on voltages higher than 600 volts should comply with the OSHA 29 CFR 1910 Subpart R, specifically 29 CFR 1910.269 (*Electric Power Generation, Transmission, and Distribution*), and the *Institute of Electrical and Electronics Engineers (IEEE) 2007 National Electric Safety Code*. All campuses, their agencies, and employees must understand and comply with safety standards related to electrical work and follow the uniform practices outlined in this document when engaged in electrical work.

1.3 Definitions

Arc Flash Hazard. A source of possible injury or damage to health associated with the release of energy caused be an electric arc. (NFPA 70E Art. 100)

Arc Flash Rating. The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in Calories per square centimeter (cal/cm^2). (NFPA 70E Art. 100)

Authorized Lockout/Tagout Employee. A person who locks or implements a tagout system procedure on machines or equipment to perform the servicing or maintenance on that machine or equipment. An authorized employee and an affected employee may be the same person when the affected employee's duties also include performing maintenance or service on a machine or equipment, which must be locked out, or a tagout system implemented. (Purdue LOTO Policy)

Boundary. Distance limits for various aspects of electrical work:

1. **Arc Flash Protection Boundary.** When an arc flash hazard exists, an approach limit at a distance from an arc source at which an incident energy level of 1.2 cal/cm^2.
2. **Shock Boundaries**
   a. **Limited Approach Boundary:** An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.
   b. **Restricted Approach Boundar**y: An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased risk of shock, due to electrical arc-over combined with inadvertent movement. (NFPA 70E Art. 100)

Competent person. A person meeting all of the requirements of a qualified person, and, in addition, is responsible for all work activities or safety procedures related to custom or special equipment, and has detailed knowledge regarding the electrical hazard exposure, the appropriate controls for mitigating those hazards, and the implementation of those controls. (NFPA 70E Art. 350)

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 earth. (NFPA 70E Art. 100)

Disconnecting (or Isolating) Switch (Disconnector, Isolator). A mechanical switching device used for isolating a circuit or equipment from a source of power. (NFPA 70E Art. 100)

Electrical Infrastructure. Electrical components, including breaker and fuse panels, light switches and fixtures, switchboards, wiring, etc., that facilitate the use and transfer of electrical energy. (Purdue University Definition)

Electrically Safe Work Condition. A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection. (NFPA 70E Art. 100)

Electrical Work – Normal Operation. Work performed to start up or shut down electric equipment that meets the criteria of Normal Operation in Chapter 6 introduction. This work may be performed by trained individuals who would not be exposed to energized parts or an arc flash hazard and may be of non-electrical occupations. (Purdue University Definition)

Examples include operation of circuit breaker, switch, contactor or starter for control of hazardous energy isolation.

Electrical Work – Maintenance, Inspection, Troubleshooting, Construction. Work performed on electrical equipment while exposed to energized conductors or circuit parts; interaction with or operation of electrical equipment where an arc flash hazard is likely or other abnormal conditions are present. The work should only be performed by electrically qualified persons. (Purdue University Definition)

Energized. Electrically connected to or is, a source of voltage. (NFPA 70E Art. 100)

Evidence of Impending Failure. Evidence such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration. (NFPA 70E Art. 130)

Exposed electrical 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. (NFPA 70E Art. 100)

Fault Current, Available. The largest amount of current capable of being delivered at a point on the system during a short circuit condition. (NFPA 70E Art. 100)

Facilities. As used in these regulations, the term "University Facility" or "University Facilities" means any building or structure or any improved or unimproved land, or any part of any such building, structure, or land, which is owned, used, or occupied by Purdue University and where employees may be exposed to occupational hazards. (Purdue University Definition)

Field Evaluated. A thorough evaluation of non-listed or modified equipment in the field performed by persons or parties acceptable to the Authority Having Jurisdiction (AHJ). The evaluation approval ensures that the equipment meets appropriate codes and standards, or is similarly found suitable for a specified purpose. (NFPA 70E Art. 350)

Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth. (OSHA 29 CFR 1910.399)

Ground Fault Circuit Interrupt (GFCI). A device intended for the protection of personnel that functions to deenergize a circuit or a portion of a circuit within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit. (OSHA 29 CFR 1910.399)

Hazard Assessment. Process of identifying hazards and associated with a defined task and prescribing personal protective equipment (PPE) along with other relevant protection measures which must be employed to reduce the risk from the hazards. (Purdue PPE Policy)

Hazardous Location. An area in which an airborne flammable dust, vapor or gas may be present and would represent a hazard if a source of ignition were present (see NFPA Class I & II and Division 1 & 2). (NFPA 497)

Laboratory. A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostics, product testing, or use of custom or special electrical components, systems, or equipment. (NFPA 70E Art. 350)

Listed. Equipment, materials or services included in a list published by an organization that is acceptable to AHJ 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 they meet appropriate designated standards or has been tested and found suitable for a specific purpose. (NFPA 70E Art. 100)

Location, Damp. Partially protected locations subject to moderate degrees of moisture, such as some basements, barns and cold-storage warehouse. (OSHA 29 CFR 1910.399)

Location, Dry. Locations not normally subject to dampness or wetness. (OSHA 29 CFR 1910.399)

Location, Wet. Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations unprotected and exposed to weather. (OSHA 29 CFR 1910.399)

Lockout/Tagout. A standard that covers the servicing and maintenance of machines and equipment in which the unexpected re-energizing or startup of the machines/equipment or release of stored energy could cause injury to employees. It establishes minimum performance requirements for the control of such hazardous energy. (Purdue LOTO Policy)

Maintenance, Condition of. The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices. (NFPA 70E Art. 100)

Motor Control Center. A modular assembly specifically designed to plug in motor control units. Motor control centers are supplied by a common bus, usually straight from the switchboard. (NFPA 70E Art. 100)

Panelboard. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (NFPA 70E Art. 100)

Personal Protective Equipment (PPE). Equipment such as protective clothing, respiratory device, shields and barriers used to protect against hazards and irritants capable of causing injury or impairment through absorption, inhalation or physical contact. (Purdue PPE Policy)

Properly Installed. The equipment is installed in accordance with applicable industry codes and standards and the manufacturer's recommendations. (NFPA 70E Art. 130)

Properly Maintained. The equipment has been maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards. (NFPA 70E Art. 130)

Qualified Person. One who received training and has demonstrated skills and knowledge in the construction and operation of equipment or a specific work method and be trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method.

Notes:

1. Whether a person is considered to be a “qualified” person will depend upon various circumstances in the workplace. It is possible and, in fact, likely for an individual to be considered “qualified” with regard to certain equipment or tasks in the workplace, but “unqualified” as to other equipment or tasks.
2. An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties. (NFPA 70E Art. 110, OSHA 29 CFR 1910.399)

Research and Development (R&D). An activity in an installation specifically designated for research or development that may be conducted with custom or special electrical equipment. (NFPA 70E Art. 350)

Risk. A combination of the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard. (NFPA 70E Art. 100)

Risk Assessment. An overall process that identifies hazards, estimates the potential severity of injury or damage to health, estimates the likelihood of occurrence of injury or damage to health, and determines if protective measures are required. (NFPA 70E Art. 100)

Service. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served. (OSHA 29 CFR 1910.399)

Service Equipment. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the entrance of supply conductors to the building and intended to constitute the main control and means of cutoff of the supply. (OSHA 29 CFR 1910.399)

Switchboard. A large single panel, frame, or assembly of panels on which are mounted, on the face or back, or both, switches, overcurrent and other protective devices, buses, and (usually) instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (OSHA 29 CFR 1910.399)

Switching Devices. Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, interrupter switches, and oil (filled) cutouts. (OSHA 29 CFR 1910.399)

Voltage (of a circuit). The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned. (NFPA 70E Art. 100)

Voltage, nominal. An approximate value assigned to a circuit or system for the purpose of conveniently designating its voltage class, e.g., 120/240, 480/277, and 600. (NFPA 70E Art. 100)

Working Distance. The distance between a person’s face and chest area and a prospective arc. (NFPA 70E Art. 100)

Working On (energized electrical conductors or circuit parts). Coming in contact with energized electrical conductors or circuit parts with hands, feet, or other body parts, with tools, probes or with test equipment, regardless of the personal protective equipment a person is wearing. There are two categories of "working on": *Diagnostic (testing)* is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; *repair* is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.). (NFPA 70E Art. 100)

1.4 Responsibilities

OSHA compliance requires Purdue University to:

- Provide and demonstrate a safety program with defined responsibilities
- Provide and document employee training covering Lockout/Tagout procedure, Energized Work permit, and the hazards of arc flash
- Provide PPE for workers
- Provide appropriate tools for safe work
- Have qualified personnel determine the degree of arc flash hazard
- Affix warning labels on equipment

The ESP and fieldwork shall be audited to verify the principles and procedures of the program comply with this plan. The audit shall be documented its frequency shall not exceed 3 years. Each department will determine the assignment of the following responsibilities based on staff expertise, resources and agency specific considerations.

Purdue University OSHA Officer

- Responsible for Safety Compliance

Senior Engineers and Staff

- Review designs and provide consultation for compliance with the National Electric Code during construction, renovation, and repair of electrical equipment.
- Provides technical oversight to the Arc Flash Coordinator & staff

Arc Flash Coordinator and Staff

- Coordinate and complete electrical studies for secondary facility electrical systems
- Electrical studies include: as-built data collection, electrical one-line modeling, protective device coordination, equipment evaluation, arc flash hazard analysis
- Label equipment to communicate electrical hazards and appropriate PPE requirements
- Maintain database of electrical studies and one-line diagrams; update at least every 5 years

- Review consultant-performed electrical studies for compliance with Purdue standards and requirements of *NFPA 70E*
- Place an emphasis on controlling electrical hazards through the application of engineering and design controls
- Promote consistency in electrical installations throughout the various facilities

Senior Directors/Deans

- Provide resources for compliance with the Electrical Safety program.

Directors/Department Heads

- Ensure that supervisors and employees have an understanding of and comply with the Electrical Safety program

Safety Managers/Training Coordinators

- Assist units to implement the ESP
- Provide or coordinate ESP general training for work units
- Provide or assist with specific training for electrical work qualifications
- Maintain all training records
- Evaluate work and determine compliance with the ESP
- Periodically evaluate the overall effectiveness of the ESP
- Periodically review and update the written ESP

Supervisors

- Promote electrical safety awareness to all employees
- Ensure employees comply with ALL provisions of the ESP
- Ensure employees receive training appropriate to their assigned electrical tasks
- Document training for assigned electrical tasks
- Develop and maintain a listing of all qualified employees under their supervision
- Ensure employees are provided with and use appropriate protective equipment
- Ensure employees comply with the Control of Hazardous Energy Program (Lockout/Tagout)

Employees

- Follow the work practices described in this ESP
- Use appropriate protective equipment and tools
- Attend all required ESP related training
- Immediately report any electrical safety concerns to supervision

Qualified Electrical Workers

- **Departmental** qualified electrical workers are expected to test, troubleshoot, and maintain departmental electrical equipment (e.g., X-ray machines, lathes, experimental apparatus etc.) not maintained by Physical Facilities.
- **Physical Facilities** qualified electrical workers are expected to test, troubleshoot, and maintain building electrical equipment and distribution infrastructure.

1.5 Basic Electrical Safety Principles

Electricity is dangerous when used without proper training, knowledge and planning. The basic electrical safety principles listed below provide guidance to use electricity safely before you start a job.

- Obtain Training: Ensure every employee receives the appropriate training to make them qualified electrical workers for the job they are expected to perform.
- Plan Every Job: If a job requires working on live circuits (the energized condition), the employer must have or develop a systematic procedural checklist for doing the work. Discuss the hazards and procedures before starting each job. Document any new procedures.
- Identify Hazards. Conduct hazard analysis for the job and identify steps that could create electric shock or arc-flash hazards.
- Minimize Hazards. De-energize equipment unless it introduces a greater hazard. Insulate or isolate exposed live parts to avoid contact. Use appropriate PPE and electrically safe tools.
- De-energize If Possible: An Energized Work Permit is required to do any energized work beyond testing and troubleshooting.
- Anticipate Problems: Plan for the worst-case scenario. Have the proper PPE and tools immediately available.

Chapter 2: Training Requirements

All employees should have electrical safety training to be aware of electrical hazards that may be encountered in their work and how to protect themselves from those hazards. The level of training should be commensurate with the level of hazard exposure.

Electrical Safe Work Practices training is required for anyone working near energized, or potentially energized electrical circuits of fifty (50) or more volts to ground or is exposed to an arc flash hazard. Training shall be provided when an employee is initially assigned to the job and prior to performing energized electrical work. Trained personnel must demonstrate a working knowledge of the relevant electrical codes.

Training shall also be provided to employees who are not exposed to energized parts, but will operate electrical equipment (e.g., pumps, heating, air conditioning, and refrigeration machinery) during normal operations.

Environmental Health and Safety (EHS) has an online awareness level Electrical Safety training module for employees whose jobs do not require them to be Qualified Electrical Workers. In addition Electrical Safe Work Practices training is available upon request. Contact EHS for more information.

2.1 Initial Training

There are two versions of initial training available, 1) Electrical Work – Normal Operation and 2) Qualified Electrical Worker – Maintenance, Inspection, Troubleshooting, Construction. The type of electrical work determines the initial training requirements.

2.1.1 Electrical Work – Normal Operation

Electrical Work training must cover avoiding electrical hazards associated with work inside shock approach and arc flash boundaries of exposed energized parts.The following topics are to be included in all electrical safety training.

- Hazardous effects of electricity on the human body
- Universal electrical safety practices.
- Hazards associated with power electronic equipment.
- How to read arc flash warning labels to gauge extent of potential hazards.
- Purdue University Control of Hazardous Energy (Lockout/Tagout) Program training and safe work practices required to safely de-energize electrical equipment.

2.1.2 Qualified Electrical Worker – Maintenance, Inspection, Troubleshooting, Construction

Only a Qualified Electrical Worker is allowed to work on energized circuits within the Limited Approach and Arc Flash Boundaries. Qualified electrical workers shall not work alone

(except for replacing fuses; operating switches, or other operations that do not require contacting energized voltage conductors or parts of equipment; and clearing trouble or emergencies involving hazards to life or property).

In addition to training outlined in 2.1.1, qualified electrical workers must be familiar with the proper use of special precautionary techniques; PPE (including arc-flash suit); insulating and shielding materials, insulated tools and test equipment, arc flash analysis labels; and NFPA 70E tables.

Qualified electrical workers must know how to properly select and use:

- Best work practices
- Appropriate insulating and shielding materials
- Tools and equipment for working on or near energized parts
    - A device to verify the absence of voltage
    - An appropriate voltage detector
    - PPE determined from the arc flash label, NFPA 70E Table 130.5(G), NFPA 70E Table 130.7(C)(15), and/or Purdue PPE Policy.

In addition, qualified electrical workers must have knowledge and understanding as well as skills and techniques necessary to:

- Interpret indications provided by a device to verify the absence of voltage
- Recognize limitations specific types of voltage detectors
- Determine the nominal voltage of exposed live parts
- Distinguish exposed live parts from other parts of electric equipment.
- Determine the approach distances corresponding to the voltages specified in the following NFPA 70E tables:
    - NFPA 70E Table 130.4(D)(a) Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection for Alternating-Current Systems
    - NFPA 70E Table130.4(D)(b) Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection, Direct-Current Voltage Systems
- Avoid the electrical hazards associated with work inside shock approach and arc flash boundaries of exposed energized parts
- Determine hazards, risks as well as appropriate protective clothing and equipment requirements using arc flash analysis labels or the following NFPA 70E tables:
    - NFPA 70E Table 130.5(C) Estimate of the Likelihood of an Arc Flash Incident for AC and DC Systems
    - NFPA 70E Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Analysis Method Is Used
    - NFPA 70E Table130.7(C)(15)(a) Arc-Flash Hazard PPE Categories for Alternating Current (ac) Systems

    - NFPA 70E Table 130.7(C)(15)(b) Arc-Flash Hazard PPE Categories for Direct Current (dc) Systems
    - NFPA 70E Table 130.7(C)(15)(c) Protective Clothing and Personal Protective Equipment (PPE)
- Recognize the signs and symptoms of electric shock, heart fibrillation, electric burns and contacting emergency personnel at 911

For copies of NFPA 70E tables contact EHS.

2.2 Retraining

Mandatory retraining (or refresher) training is required a minimum of every three (3) years or when conditions change. The interval between retraining shall not exceed 36 months. In addition, an employee must receive additional training (or retraining) when any of the following conditions are met:

- Supervision or annual inspections indicate that the employee is not complying with the established safety-related work practices
- Safety-related work practices not normally used during regular job duties are employed
- New technology, new types of equipment, or changes in procedures require using safety-related work practices different from those normally used

2.3 Documenting Training and Experience

Each department shall document and maintain electrical training and experience. Documentation is necessary to demonstrate that individuals have met the training and experience requirements for the types of work they performed. The documentation shall contain the training content and be maintained for the duration of employment. For an example of an Electrical Safety Training Checklist, see Appendix F.

Chapter 3: Electrical Protective Equipment

3.1 General Requirements

Electrical protective equipment must meet the criteria established by the **American Society of Testing and Materials (ASTM)** and by the **America National Standards Institute (ANSI).** Equipment shall include rated arc flash apparel, eye protection, head protection, hand protection, hearing protection, insulated footwear, and face shields where necessary. PPE must be maintained in a safe, reliable condition and be inspected by the qualified wearer for damage before each day's use and immediately following any incident that can reasonably be suspected of having caused damage. Protective equipment that becomes damaged contaminated with grease, oil flammable liquids, or combustible liquids shall not be used.

Each department must provide any electrical protective equipment required by this program for employees working in areas where there are potential electrical hazards. The PPE must be appropriate for the specific work to be performed. Electrical tools and protective equipment must be specifically approved, rated, and tested for the levels of voltage of which an employee may be exposed. If an arc flash hazard is present, then additional PPE is required, including arc-resistant clothing and hardhat with arc rated face shield is required.

3.2 Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) shall be worn whenever qualified workers are inside the Arc Flash Boundary of energized equipment or Restricted Approach Boundary of exposed energized parts (using the greater of the two distances). The required PPE can be determined from the incident energy value listed on the equipment’s arc flash label. If an arc flash analysis has not been done, then Arc Flash Category Classification and PPE tables in *NFPA 70E* should be consulted. Copies of Approach Boundary, Arc Flash Category Classification and Protective Clothing/PPE tables are available from the EHS.

The Minimum PPE for Normal Operation of electrical powered equipment is safety glasses and leather gloves. The minimum PPE required for electrical work that does not meet the criteria of Normal Operation of electric equipment is long sleeve shirt (natural fiber), long pants (natural fiber), safety glasses or goggles, hearing protection (foam inserts) and leather gloves. **PPE must be donned prior to starting electrical work.** Employees shall wear at least the following:

- Eye protection whenever there is a danger of injury from electric arcs, flashes, or from flying objects resulting from an electrical explosion
- Nonconductive head protection whenever there is a danger of head injury from electric shock or burns due to contact with live parts or from flying objects resulting from an electrical explosion
- Rubber insulated gloves where there is a danger of hand or arm contact with live parts or possible exposure to arc flash burn
- Voltage rated gloves with leather protectors when using electrical testing meters on exposed energized electrical conductor or circuit parts 50 volts and above

- Dielectric overshoes when insulated footwear is used as protection against step and touch potential. Insulated soles shall not be used as primary electrical protection.

Protective shields, barriers, or insulating materials must be used to protect each employee from shock, burns, or other electrical injuries while that person is working near exposed energized parts that might be accidentally contacted or where dangerous electric heating or arcing might occur. Face shields without arc rating shall not be used for electrical work. Safety glasses or goggles must always be worn underneath face shields. Additional illumination may be needed when using tinted face shields as protection during electrical work.

Arc Rated Apparel & Under layers worn to protect an employee must cover potentially exposed areas as completely as possible, cover all ignitable clothing, and allow for movement and visibility. Arc-resistant shirtsleeves must be fastened at the wrist and arc-resistant shirts or jackets must be closed at the neck. Arc-rated garments worn as outer layers over arc-rated apparel (i.e., jackets or rainwear) must also be made from arc- rated material. Arc-Rated flash suits must permit easy and rapid removal by the user. Follow the garment manufacturer's instructions arc-resistant apparel care and maintenance in order to maintain protective properties.

Non-melting, flammable garments (e.g., cotton, wool, rayon, silk, or blends) may be used as under layers beneath arc-resistant apparel; however, arc-resistant undergarments are recommended. Melting fibers such as acetate, nylon, polyester, polypropylene, and spandex is not permitted in fabric under layers next to skin; however, an incidental amount of elastic on non-melting fabric underwear or socks is permitted.

3.3 Insulating Materials and Tools

Employees must use insulated tools and handling equipment rated for the voltages encountered when working inside the Limited Approach Boundary and Restricted Approach Boundary near exposed energized circuits, conductors, or parts. Insulated tools must be designed and constructed to meet the demands of use and the environment to which they are exposed. Insulating equipment made of materials other than rubber shall provide electrical and mechanical protection at least equal to that of rubber equipment. If the insulating capability of protective equipment is subject to damage during use, the insulating material must be protected by an outer covering of leather or other appropriate material.

Insulating rubber equipment such as gloves, sleeves, blankets, and matting must be stored in an area protected from light, temperature extremes, excessive humidity, ozone, and other substances and conditions that my cause damage. In addition to being tested according to the schedule supplied by the manufacturer, rubber insulated equipment must be

- Inspected for damage before each day's use
- Air tested before each use
- Inspected immediately following any incident that could have caused damage

- Dielectrically tested within 6 months of first use or 1 year of purchase if not used (rubber gloves used without the leather protectors must be removed from service until dielectrically tested)

Rubber insulated equipment found to have defects that might affect its insulating properties must be removed from service until testing indicates that it is acceptable for continued use. Do not attempt to repair defective rubber insulated equipment.

Fuse handling equipment insulated for the circuit voltage shall be used to remove or install a fuse if the terminals are energized. Ropes and hand-lines used near exposed energized parts shall be nonconductive and portable ladders used for electrical work shall have nonconductive side rails. Tools and handling equipment should be replaced if the insulating capability is decreased due to damage.

3.4 Access Limiting Equipment

Specific training and qualifications are required to work with electricity. Electrical work zones must always be secured to prevent access by unqualified individuals for their safety and the safety of the qualified personnel. Often, electrical work is performed in areas where the general public could be exposed to the hazards. The bullet points listed below shall be followed to reduce the hazards to unqualified people.

- Barricades shall be used in conjunction with safety signs to prevent or limit access to work areas containing live parts. Barricades must be of sturdy construction and discourage access. An example would be temporary fencing. Conductive barricades shall not be used where they might cause an electrical hazard. Barricades shall be placed no closer than the Limited Approach Boundary.
- If signs and barricades do not provide sufficient protection, an attendant will be assigned to warn and protect pedestrians. The primary duty of the attendant shall be to keep an unqualified person out of the work area where an electrical hazard exists. The attendant shall remain in the area as long as there is a potential exposure to electrical hazards.
- If any area accessible to unqualified people is left unattended, the area must be returned to an electrically safe condition (e.g., Panelboard covers replaced). Barricades and signs are not an acceptable safeguard.

Chapter 4: Identifying Electrical Hazards

4.1 Hazard Identification and Risk Assessment

Before any work, including testing and troubleshooting can take place an electrical hazard assessment and risk assessment must be done. An Electrical Work Hazard Assessment for form can be found in Appendix D. The hazard assessment includes identifying the following:

- Shock, arc flash, and arc blast hazards
- Non-electrical hazards (e.g., falls, confined space, chemical, biological, radiation, and environmental hazards)
- Means of mitigating hazards through engineering controls, administrative controls, and PPE
- If an Energized Electrical Work Permit is required

In addition to the electrical hazard assessment, a risk assessment of common electrical tasks must be done rating the relative hazards of electrical tasks. The risk assessment can be used to:

- Identify hazards
- Assess risks
- Implement the hierarchy of risk controls:
    - Elimination
    - Substitution
    - Engineering
    - Warnings
    - Administration
    - PPE

For more details, see Hazard and Risk Assessment forms in the Appendix D.

4.2 Hazardous Effects of Electricity on the Human Body

Results of Power Frequency Current

- At 5 mA, shock is perceptible.
- At 10 mA, a person may not be able to voluntarily let go of the hazard.
- At about 40 mA, the shock, if lasting for 1 second or longer, may be fatal due to ventricular fibrillation.
- Increasing current leads to burns and cardiac arrest.

Results of Direct Current (DC)

- A DC current of 2 mA is perceptible.
- A DC current of 10 mA is considered the threshold of the let-go current.

Results of Voltage

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

Results of Short Contact

- For contact less than 0.1 second and with currents just greater than 0.5 mA, ventricular fibrillation may occur only if the shock is in a vulnerable part of the cardiac cycle.
- For contact of less than 0.1 second and with currents of several amperes, ventricular fibrillation may occur if the shock is in a vulnerable part of the cardiac cycle.
- For contact of greater than 0.8 second and with currents just greater than 0.5 A, cardiac arrest (reversible) may occur.
- For contact greater than 0.8 second and with currents of several amperes, burns and death are probable.

Results of Alternating Current (AC) at Frequencies above 100 Hz

- When the threshold of perception increases from 10 kHz to 100 kHz, the threshold of let-go current increases from 10 mA to 100 mA.

Effects of Wave shape

- Contact with voltages from phase controls usually causes effects between those of ac and dc sources.

Effects of Capacitive Discharge

- A circuit of capacitance of 1 microfarad having a 10 kV capacitor charge may cause ventricular fibrillation.
- A circuit of capacitance of 20 microfarad having a 10 kV capacitor charge may be dangerous and probably cause ventricular fibrillation.

4.3 Power Electronic Equipment and Electricity

Employer and employees shall be aware of the hazardous effects of electricity on the human body and hazards associated with power electronic equipment

Power electronic equipment includes the following types of devices:

- Electric arc welding equipment
- High-power radio, radar, and television transmitting towers and antenna
- Industrial dielectric and radio frequency (RF) induction heaters
- Shortwave or RF diathermy devices

- Process equipment that includes rectifiers and inverters such as the following:
- Motor drives
- Uninterruptible power supply systems
- Lighting controllers

4.4 Hazards Associated with Power Electronic Equipment

Employer and employees shall be aware of the hazards associated with the following:

- High voltages within power supplies
- RF energy–induced high voltages
- RF fields near antennas and antenna transmission lines can cause electrical shock and burns
- Radiation
    - Ionizing X-radiation (X-ray) hazards from magnetrons, klystrons, thyratrons, cathode-ray tubes, and similar devices
    - Non-ionizing RF radiation from:
        - Industrial microwave heaters and diathermy radiators
        - Industrial scientific and medical equipment
        - Radar equipment
        - Radio communication equipment, including broadcast transmitters
        - RF induction heaters and dielectric heaters
        - Satellite–earth-transmitters

Chapter 5: Minimizing Electrical Hazards

5.1 Arc Flash Hazard Analysis Implementation

In 2011, Physical Facilities developed and implemented a five-year plan to conduct arc flash hazard analyses of all University facilities. The goal is to identify high hazard equipment and reduce the hazards of maintaining it through engineering controls. Arc flash analyses will identify equipment that has a greater potential for arc flash as well as help ensure the safety of qualified electrical workers who frequently use of arc flash category PPE.

Arc flash hazard analysis consists of collecting data on the power distribution system. The arrangement of components is documented on a one-line drawing with nameplate specifications of every device and lengths and cross-section area of all cables.

The electric utility is consulted to get information including the minimum and maximum fault currents that can be expected at the entrance to the facility. Subsequently, a short circuit analysis followed by a coordination study is completed. *SKM Arc Flash Analysis* software then uses the resultant data to calculate (2018 edition of *NFPA 70E* or I*EEE Standard 1584 2018* equations) the arc flash protection boundary distances and incident energies. Those calculated boundary distances and energies are then used to determine minimum PPE requirements.

For systems of 600 volts and less where an arc flash analysis has not been performed, *NFPA 70E* Arc Flash Category Classification tables 130.7(C)(15)(a) and 130.7(C)(15)(b) will provide arc flash boundary distance, provided it meets the maximum short circuit current and fault clearing time criteria. For other fault currents and clearing times greater than those listed in the *NFPA 70E* tables, an arc flash analysis must be performed as well.

The Arc Flash Analysis Team staff shall complete an arc flash hazard analysis as required by *NFPA 70E*. Arc flash hazard analysis shall be done under the supervision of a licensed electrical engineer; for all major electrical system upgrades or renovations; and for all new electrical system installations.

5.1.1 West Lafayette Campus

The Arc Flash Analysis Team staff has completed an arc flash hazard analysis as required by NFPA 70E for buildings on West Lafayette campus.

5.1.2 Other Purdue University Properties and Facilities

Arc flash analysis has not been completed for all buildings on regional campuses Purdue Northwest, Purdue Fort Wayne and other satellite sites such as Purdue Agricultural Centers and Statewide Technology Centers

Until an arc flash hazard analysis can be done, a qualified electrical worker will use *Arc-Flash PPE Categories for ac and dc Systems,* NFPA 70E Tables 130.7(C)(15)(a), 130.7(C)(15)(b) and 130.7(C)(15)(c) to determine the arc-flash category for PPE selection.

5.2 Electrical Equipment Labeling

Switchboards, panel boards, industrial control panels, motor control centers, disconnects and any other equipment posing an arc flash hazard will be field marked (labeled) to warn workers of potential electric arc flash hazards. When arc flash and shock data are available for industrial control panels, labels shall include information on arc flash hazard boundary, the hazard category, required PPE, minimum arc rating, limited approach distances, restricted approach distances and prohibited approach distances. Labels shall be of the type, or similar to, the example labels shown in Appendix B.

Labeling is intended to reduce the occurrence of serious injury or death due to arcing faults to workers working on or near energized electrical equipment. Labels shall be located so they are visible to the personnel before examination, adjustment, servicing, or maintenance of the equipment. The top and bottom of the Purdue University Arc Flash and Shock Hazard labels are color coded to reflect the arc flash category range of calculated incident energy. There are two system of labeling (see Table 5.1 and 5.2).

Table 5.1 – Arc Flash and Shock Hazard Label Legend (Prior to 2015)

Arc Flash Category	Incident Energy Range (cal/cm^2)	Arc Flash (Bottom Color)	Type of Label (Top Color)
0	Less than 1.2	White	Warning
1	1.2 – 4	Green	Warning
2	4 – 8	Yellow	Warning
3	8 – 25	Orange	Warning
4	25 – 40	Red	Warning
Dangerous	Greater than 40	Red	Danger

Table 5.2 – Arc Flash and Shock Hazard Label Legend (2015 to Present)

Incident Energy Range (cal/cm^2)	Arc Flash (Bottom Color)	Type of Label (Top Color)
Less than 1.2	White	Warning
1.2 – 40	Orange	Warning
Greater than 40	Red	Danger

Chapter 6: Working On or Near Energized Electrical Equipment

The most important principle of electrical safety is to assume all electric circuits are energized unless each involved worker ensures they are not. Every circuit and conductor must be tested every time work is done on it. Proper PPE must be worn until the equipment is proven de-energized. **The process of de-energizing is "energized" work and can result in an arc flash due to equipment failure.** Both *NFPA 70E* 130.1 and OSHA 1910.333 state:

> *Energized electrical conductors and circuit (live) parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works (on or near) within the Limited Approach Boundary of those conductors or parts,* ***unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations****.*
>
> *Energized electrical conductors and circuit (live) parts that operate at less than 50 volts to ground need not be de-energized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.*

Examples of increased or additional hazards include, but are not limited to:

- Interruption of life support equipment
- Deactivation of emergency alarm systems
- Shutdown of hazardous location ventilation equipment

Departments must provide training and adopt written standard operating procedures (SOPs) for common tasks where work on or near live circuits may be required. When working on live circuits an employee is actually touching energized parts with tools. When working near live circuits, an employee inside the restricted approach boundary is close enough to energized parts to pose a risk, even though other parts are de-energized. Common tasks include:

- Opening electric equipment doors for inspection
- Opening and closing disconnects and breakers
- Taking voltage measurements
- Racking breakers on and off the bus
- Removing panels and dead fronts

Example SOP statement:

> *“When opening and closing disconnects, use the “left-hand rule” when possible. Stand to the right side of the equipment and operate the disconnect switch with the left hand.”*

Normal Operation of Electric Equipment

Normal Operation of electrical powered equipment shall be permitted where all of the following conditions are satisfied:

1. The equipment is properly installed.
2. The equipment is properly maintained
3. The equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.
4. The equipment doors are closed and secured.
5. All equipment covers are in place and secured.
6. There is no evidence of impending failure such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.

Use of the information on the arc flash hazard label and Table 130.5(C) provides guidance on assessing criteria for Normal Operation and the likelihood of an arc flash occurrence.

For any electrical equipment where an arc flash hazard may be present, a hazard assessment shall be performed by an electrically qualified worker on the equipment to ensure it meets the criteria for Normal Operation. The arc flash analysis coordinator and electrical engineers in Engineering Services are available to assist. The hazard assessment should be documented and noted in the equipment SOP.

Conditions that do not meet the criteria of Normal Operation are consider abnormal operation and an electrical hazard assessment should be performed to determine necessary electrical safe work practices and PPE.

6.1 Energized Electrical Work Permits

When energized work is authorized, an energized electrical work permit shall be required under the following conditions:

- When work is performed within restricted approach boundary of exposed energized parts.
- When the employee interacts with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from exposure to an arc flash hazard exists from abnormal operations.

The intent of the permit is to ensure that all appropriate safety precautions are taken prior to performing energized electrical work. The Electrical Work Hazard Assessment, which includes the Energized Work Permit can be found on the EHS website under the "Forms" section.

6.1.1. Use of Energized Work Permit

The permit must be originated by the qualified electrical worker and submitted to their appropriate department supervisor for signature approval. The permit must be posted in an appropriate and obvious location where the energized work is taking place for the duration

of the task. After the energized electrical work has been completed, send a copy of the completed work permit to EHS.

6.1.2. Exemptions to Energized Work Permit

An energized electrical work permit shall not be required if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with this plan under any of the following conditions:

- Testing, troubleshooting and voltage measuring
- Thermography and visual inspections if the restricted approach boundary is not crossed
- Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed.

6.2 Approach Distances to Exposed Energized Parts

NFPA 70E defines three (3) boundaries for electrical work. Two (2) boundaries are approach distances related to shock hazards and the third boundary is related to arc flash protection. Approach boundary tables are available from EHS's Occupational Safety section.

6.2.1 Shock Protection Boundaries

The distance for the Limited and Restricted Approach boundaries are found in NFPA 70E tables 130.4(D)(a) and (b).

Within the **limited approach boundary**, unqualified persons should not be inside the boundary unless escorted by a qualified person and informed of potential safety hazards.

Within the **restricted approach boundary**, only qualified persons with proper PPE and tools may cross. Inside this boundary, accidental movement can put a part of the body or conductive tools in contact with live parts or inside the prohibited approach boundary. To cross the restricted approach boundary, the qualified person must:

1. Perform hazard identification and risk assessment
2. Have an energized work permit that is approved by the supervisor when performing work beyond testing and trouble shooting
3. Use PPE rated for working near exposed energized parts and rated for the voltage and energy level involved
4. Ensure that no part of the body enters the prohibited space
5. Minimize risks from unintended movement by keeping as much of the body as possible out of the restricted space (body parts in the restricted space should be protected)

6.2.2 Arc Flash Protection Boundary

Arc Flash Analysis has been performed

When interacting with electrical equipment within the Arc Flash Protection Boundary, protective equipment and measures are required. The qualified person must:

1. Determine if interaction meets the criteria for Normal Operation of electric equipment. A hazard identification assessment should be done with the arc flash hazard label and Table 130.5(C) to provide guidance on assessing the likelihood of an arc flash occurrence. Arc – rated PPE may not be required for Normal Operation of electric equipment.
2. If criteria for Normal Operation is not met, arc flash PPE is necessary to continue work.
3. Use PPE appropriate for working near exposed energized parts and rated for the voltage and energy level involved.

If an arc flash analysis has been performed, a qualified person can use the incident energy value on the arc flash analysis label and the arc flash hazard Table 130.5(G) to specify arc – rated clothing and other PPE.

Arc Flash Analysis has not been performed

For systems of 600 volts and less where an arc flash analysis has not been performed and no incident energy levels are listed:

1. Use Table130.7(C)(15)(a) and/or Table 130.7(C)(15)(b) to determine the arc-flash PPE category.
2. Use Table 130.7(C)(15)(c) to choose the appropriate clothing and PPE
3. Table 130.4(D)(a) and/or Table 130.5(D)(b) will provide the limited and restricted approach boundaries.
4. Table130.7(C)(15)(a) and/or Table 130.7(C)(15)(b) will provide arc flash boundary distance, provided the equipment meets the maximum short circuit current and fault clearing time criteria in the tables

For copies of NFPA 70E tables contact EHS.

Chapter 7: Working on De-Energized Electrical Equipment

7.1 Lockout/Tagout Program

Each department shall follow the written Purdue University Control of Hazardous Energy (Lockout/Tagout) Program and train employees in the program. Written lockout/tagout procedures should be developed for each machine or piece of equipment that will require servicing. The program should cover planning for

- Locating and labeling energy sources
- Identifying at-risk employees, who de-energized the equipment and how
- Releasing of stored energy
- Verifying that the circuit is de-energized and can't be restarted
- Voltage testing
- Grounding requirements
- Shift changes
- Coordination with other jobs in progress and a procedure for keeping track of all involved personnel
- Applying and removing lockout/tagout devices
- Return to service
- Temporary re-energizing for testing/positioning

7.2 Electrically Safe Condition

The 2018 edition of *NFPA 70E* lists six steps to ensure for electrically safe work conditions. Always follow these steps.

1. Identify all sources of power to the equipment. Check applicable up-to-date drawings, diagrams, and identification tags.
2. Remove the load current, and then open the disconnecting devices for each power source.
3. Where possible, visually verify that blades of disconnecting devices are fully open or that drawout-type circuit breakers are fully withdrawn.
4. Apply lockout/tagout devices in accordance with a Purdue’s Control of Hazardous Energy Program
5. Test each phase conductor or circuit part with an adequately rated voltage detector to verify that the equipment is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Check the voltage detector before and after each test to ensure it is working.
6. Properly ground all possible sources of induced voltage and stored electric energy (such as, capacitors) before touching. If conductors or circuit parts that are being de-energized could contact other exposed conductors or circuit parts, apply ground-connecting devices rated for the available fault current.

7.3 Other Precautions

When working on de-energized parts, but still inside the arc flash protection boundary for nearby energized exposed parts:

- If the parts cannot be de-energized, barriers (e.g., insulated blankets) must be used to protect against accidental contact or PPE must be worn.
- Employees shall not reach blindly into areas that might contain exposed live parts.
- Employees shall not enter spaces containing energized parts unless illumination is provided that allows the work to be performed safely.
- Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) shall not be worn where they present an electrical contact hazard with exposed live parts.
- Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall not be handled inside the Limited Approach Boundary. If this is not possible, they shall be handled in a manner that prevents accidental contact with live parts. Such materials and equipment include, but are not limited to long conductive objects such as ducts, pipes, tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.
- When an employee works in a confined space or enclosed spaces (such as a manhole or vault) that contains exposed live parts, the employee shall use protective shields, barriers or insulating materials as necessary to avoid contact with these parts. Doors, hinged panels, and the like shall be secured to prevent them from swinging into employees. Refer to the EHS's confined space entry program

Chapter 8: Flexible Cords and Portable Electrical Equipment

The following requirements apply to the use of cord-and-plug-connected equipment and flexible cord sets (i.e., extension cords):

8.1 General

All cords must be inspected before each use. Employee's hands must be dry when plugging and unplugging flexible cords and cord and plug-connected equipment. If the connection could provide a conducting path to employees hands (for example, a cord connector is wet from water immersion), insulating protective equipment must be used to handle the energized plug and receptacle connections.

Flexible cords must be protected from damage. They must be designed for hard or extra hard usage (for example, types S, ST, and SO). The rating or approval must be visible. Sharp corners and projections must be avoided. They may not be run through windows or doors unless protected from damage, and then only on a temporary basis. They may not be run above ceilings; inside or through walls, ceilings, or floors; and may not be fastened with staples or otherwise hung in such a fashion as to damage the outer jacket or insulation.

Flexible cords may only be plugged into grounded receptacles. Attachment plugs and receptacles may not be connected or altered in any way that would interrupt the continuity of the equipment grounding conductor. Locking connectors must be properly locked together and must not be altered to allow the grounding pole to be inserted into current connector slots.

It is recommended that two-prong outlet receptacles be replaced with three-prong outlet receptacles. Adapters that interrupt the continuity of the equipment grounding connection may not be used. Clipping the grounding prong from an electrical plug is prohibited.

All electrical cords must be inspected for defects and damage prior to use. Refer to the following list of guidelines to determine a flexible cord’s suitability for use:

- Do not use defective or damaged cords.
- Never use an extension cord without a ground pin.
- Do not exceed the rating of the cord.
- Do not run cords across an aisle, walkways, or paths of travel in normal work areas.
- Do not run cords through doorways, ceilings, walls, or floors.
- Do not run cords above ceilings, under floors or inside walls.
- Flexible cords must remain flexible, do not permanently attach cords to any building structure.
- Do not fasten cords with staples or hang in a way that could damage the outer insulation.
- Turn off devices prior to plugging them in.
- Fully insert plug into outlet and devices into cord, keeping fingers away from metal prongs.

- Do not remove, bend, or modify any metal prongs or pins on the cord.
- Do not use excessive force to make a connection.
- Do not pull on the cord to disconnect, hold the plug to pull from outlet.
- Do not connect a three prong plug into a two prong cord outlet.

Electrical cord repair guidelines are located in Appendix E.

8.2 Extension Cords

Extension cords are considered temporary wiring and must comply with the ***Flexible Cords and Portable Electrical Equipment*** (chapter 8) and ***Temporary Wiring*** (chapter 9) requirements of this document. They may only be used for temporary power and be of the three-wire type. They should be of equal or greater thickness to the equipment cord they are plugged into.

When used with grounding type equipment extension cords must contain an equipment-grounding conductor (i.e., must accept a three-prong grounded plug). Operating equipment with an extension cord that lacks a grounding plug is prohibited. Job-made extension cords must use UL listed components and assembled by a qualified person.

Extension cords must be inspected for defects and damage prior to use. Refer to the following list of guidelines to determine an extension cord's is suitability for use:

- Do not connect extension cords in series with another extension cord or multi-tap outlet.
- Use extension cords with Ground Fault Circuit Interruption (GFCI) protection during maintenance and construction activities and in damp or wet locations.
- When not in use, store extension cords in a manner to prevent damage.
- Extension cords must be of equal or greater thickness to the device power cord they are plugged into.
- Multi outlet extension cords without circuit protection are not permitted.
- Household use extension cords are not permitted.
- Do not keep unused extension cords plugged in and energized.
- Extension cords must be rated for hard or extra hard service (usage).
    - Extension cord designations, definitions, and ratings are in Table 8.1
    - **Acceptable** extension cords for use at Purdue University are in Table 8.2
    - **Unacceptable** extension cords at Purdue University are in Table 8.3

Table 8.1 – Extension Cord Ratings Definitions and Designations

Rating	Definition and Designation
S	Service Grade, means Extra Hard Service (Usage) when not followed by J, V or P
J	Hard Service (Usage)
V	Vacuum Cleaner Cord or light duty cable
P	Parallel Cord, this is light duty
E	Thermoplastic Elastomer
O	Oil Resistant outer jacket only
OO	Oil Resistant outer jacket and conductor insulator
T	Thermoplastic
W	Outdoor use also UV resistant outer jacket and wet and damp rated conductors
H	Heater cable
VW-1	Flame retardant
FT2	Flame retardant

Table 8.2 – Acceptable Extension Cords at Purdue University (*Not a Complete Listing)*

Combined Rating	Definitions and Designations
SJEOOW	Hard Service, Thermoplastic Elastomer, Oil Resistant Jacket and Conductor, Outdoor Use
SJOW	Hard Service, Oil Resistant Jacket, Outdoor Use
SO	Extra Hard Service, Oil Resistant Jacket
SJTW	Hard Service, Thermoplastic, Outdoor Use, Hard Usage

Table 8.3 – Unacceptable Extension Cords at Purdue University *(Not a Complete Listing)*

Combined Rating	Definitions and Designations
SPT-2	Parallel cord, Thermoplastic, Indoor use, two prong, Not Hard Usage
SPT-3	Parallel cord, Thermoplastic, Indoor use, three prong, Not Hard Usage
SVE	Vacuum cleaner cord, thermoplastic elastomer, indoor use, Not Hard Usage

8.3 Portable Cord-and-Plug Devices

Portable cord and plug connected equipment and extension cords must be visually inspected before use on any shift for external defects such as loose parts; deformed and missing pins; and damage to outer jacket or insulation. The must also be inspected for possible internal damage from a pinched or crushed outer jacket. Any defective cord or cord-and-plug-connected equipment must be immediately removed from service and no person may use it until it is repaired and tested to ensure it is safe for use.

Portable equipment must be handled in a manner that will not cause damage. Do not handle electrical equipment using the cord. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.

8.4 Lamps

Lamps for general illumination must be protected from accidental contact, damage, or breakage either by elevating the fixture or by providing a suitable guard. Metal shell sockets must be grounded. Hand lamps 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. Do not suspend temporary lights by their cords unless they have been designed for this purpose.

8.5 Wet or Damp Locations

Work is prohibited in areas where there is standing water or other conductive liquids. Work in wet or damp locations (i.e., areas surrounded or near water or other liquids) should not be performed unless it is critical. If the work must be done, postpone it until standing water or conductive liquid is removed and a dry barrier is placed over wet or damp work surface surfaces.

All portable electric equipment and flexible cords used in highly conductive work locations or in places where employees are likely to contact water or conductive liquids must be approved for those locations. Use GFCI protection on electrical cords and keep them away from standing water. Do not use electrical extension cords in wet or damp locations unless they are GFCI protected. Portable lighting used in wet or conductive locations, such as tanks or boilers, must be protected by GFCIs.

Chapter 9: Temporary Wiring

Temporary electrical power and lighting installations 600 volts or less, including flexible cords, extension cords, and cables may only be used during and for renovation, maintenance, repair, or experimental work. Temporary wiring used for decorative lighting, special events, and similar purposes may not exceed 90 days. Temporary wiring shall be removed immediately following completion of the project or the purpose for which the wiring was installed. The following additional requirements apply:

9.1 Grounding and Electrical Connections

Ground-fault protection (i.e., GFCI) must be on all temporary-wiring circuits, including extension cords, used for construction or maintenance activities. In addition, equipment and tools connected by cord and plug must be grounded unless they are listed or labeled as “double insulated” tools and appliances.

Receptacles must be of the 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.

Feeders must originate in an approved distribution center, such as a panel board rated for the voltages and currents the system is expected to carry. Branch circuits must originate in an approved power outlet or panel board and suitable disconnecting switches must be installed to permit the disconnection of all ungrounded conductors of each temporary circuit. Neither bare conductors nor earth returns may be used for the wiring of any temporary circuit.

9.2 Temporary Flexible cords and Cables

Flexible cords and cables must be of a listed type and rated 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.

They may not be used as a substitute for the fixed wiring where run through holes in walls, ceilings, or floors; where run through doorways, windows, or similar openings; where attached *to building surfaces; or where concealed behind building walls, ceilings, or floors. They must be protected from accidental damage when they pass through doorways or other pinch points. Avoid sharp corners and projections.*

Chapter 10: Working Space Around Electric Equipment *(600 volts, nominal, or less)*

Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operating and maintenance of such equipment. Enclosures that house electric apparatus and are controlled by lock and key shall be considered accessible to qualified persons.

Working space for equipment operating at 600 volts, nominal, or less to ground and likely to require examination, adjustment, services or maintenance while energized shall comply with the dimensions of OSHA standard 29 CFR 1910.303(g) and OSHA Table S-1 (Table 10.1)or as required or permitted elsewhere in OSHA 1910 Subpart S (29 CFR 1910.303).

The depth of the working space in the direction of access to live parts may not be less than indicated in OSHA Table S-1. Distances shall be measured from the live parts if they are exposed or from the enclosure front or opening if they are enclosed.

The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 1.91 m (6.25 ft.) for installations built before August 13, 2007. For installations built on or after August 13, 2007, 1.98 m (6.5 ft.), except that where the electrical equipment exceeds 1.98 m (6.5 ft.) in height, the minimum headroom may not be less than the height of the equipment. *[29 CFR 1910.303(g)(1)(vi)]*

The minimum depth of clear working space at electric equipment, 600 V or less is provided in OSHA Table S-1 from 29 CFR 1910.303 (g)(1)(vi)(B).

Table 10.1 – Minimum Depth of Clear Working Space at Electric Equipment, 600 V or Less (OSHA Table S-1)

Nominal voltage to ground	Minimum clear distance for condition [2 3]					
	Condition A		Condition B		Condition C	
	m	ft.	m	ft.	m	ft.
0-150	[1]0.9	[1]3.0	[1]0.9	[1]3.0	0.9	3.0
151-600	[1]0.9	[1]3.0	1.0	3.5	1.2	4.0

Notes to Table S-1:

1. Minimum clear distances may be 0.7 m (2.5 ft.) for installations built before April 16, 1981.
2. Conditions A, B, and C are as follows:
   Condition A -- Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating material. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts.
   Condition B -- Exposed live parts on one side and grounded parts on the other side.
   Condition C -- Exposed live parts on both sides of the work space (not guarded as provided in Condition A) with the operator between.
3. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on deenergized parts on the back of enclosed equipment, a minimum working space of 762 mm (30 in.) horizontally shall be provided.

Low Voltage: Smaller working spaces can be permitted where all uninsulated parts operate at not greater than 30 volts rms, 42 volts peak, or 60 volts DC.

Existing Buildings: In existing buildings, were electric equipment is being replaced, Condition B is permitted between dead-front switch boards, panel boards, or motor control centers located across the aisle from each other where maintenance conditions and supervision ensure that written procedures have been adopted to prohibit equipment on both sides of the aisle from being open at the same time. Only qualified electrical workers who are authorized will service the installation.

Width of Working Space: The width of the working space in front of electrical equipment shall be the width of the equipment or 750 mm (30 in.) whichever is greater. In all cases, the working space shall permit at least a 90-degree opening of equipment doors or hinged panels. *[29 CFR 1910.303(g)(1)(i)(B)]*

Height of Working Space: The workspace shall be clear and extend from the grade, floor, or platform to the height required by paragraph 29 CFR 1910.303(g)(1)(vi). However, other equipment associated with the electrical installation and located above or below the electric equipment may extend not more than 153 mm (6 in.) beyond the front of the electric equipment. *[29 CFR 1910.303(g)(1)(i)(C)]*

Clear Spaces: Working space required by 29 CFR 1910.303(g) Table S-1 shall not be used for storage. When normally enclosed energized parts operating at 50 volts and more are exposed for inspection or service, the working space, if in a passageway or general open space shall be suitably guarded. *[29 CFR 1910.303(g)(1)(iii)]*

Chapter 11: Access and Entrance to Working Space

Minimum Required: At least one entrance not less than 610 mm (24 in.) wide and 1.98 m (6.5 ft.) high shall be provided to give access to the working space about electric equipment. *[1910.303(g)(1)(iii) and 1910.303(g)(1)(iv)]*

Large Equipment: On switchboard and control panels exceeding 1.83 m (6.0 ft.) in width, there shall be one entrance at each end of such boards unless the location of the switchboards and control panels permits a continuous and unobstructed way of exit travel from the work space. *[1910.303(g)(1)(iv)]*

Unobstructed Exit: Where the location permits a continuous and unobstructed way of exit travel, a single entrance to the working space shall be permitted. *[1910.303(g)(1)(iv)(A)]*

11.1 Illumination

General: Employees shall not enter spaces containing electrical hazards unless illumination is provided that enables the employees to perform the work safely. *[1910.303(g)(1)(v)]*

Obstructed View of Work Area: Employees shall not perform any task within the Limited Approach Boundary of energized electrical conductors or circuit parts operating at 50 volts or more; or where an electrical hazard exists, when there is a lack of illumination or an obstruction that prevents observation of the work to be performed.

11.2 Headroom

The minimum headroom of working spaces about service equipment, switchboards, panel boards, or motor control centers shall be 1.98 m (6.5 ft.). Where the electrical equipment exceeds 1.98 m (6.5 ft.) in height, the minimum headroom shall not be less than the height of the equipment. *[1910.303(g)(1)(vi)]*

11.3 Dedicated Equipment Space

All switchboards, panel boards, distribution boards, and motor control centers shall be located in dedicated spaces and protected from damage. Exception: Control equipment that by its very nature or because of other rules of the standard must be adjacent to or within sight of the operating machinery shall be permitted in those locations. *[1910.303(g)(1)(vii)]*

Chapter 12: Vehicular and Mechanical Equipment

When work must be performed near overhead lines, the lines shall be de-energized and grounded, or other protective measures shall be provided before work is started. 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. If protective measures (e.g., guarding, isolating, or insulating) are provided they shall prevent employees from contacting power lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

12.1 Elevated Equipment

Where any vehicle or mechanical equipment structure will be elevated near energized overhead lines, they shall be operated so that the Limited Approach Boundary distance of *NFPA 70E* Table 130.4(C), column 2, is maintained. However, under any of the following conditions, the clearances can be reduced:

If the vehicle is in transit with its structure lowered, the Limited Approach Boundary distance to the overhead lines in *NFPA 70E* Table 130.4(C), column 2, can be reduced by 6 ft. If insulated barriers, rated for the voltages involved, are installed and are not part of an attachment to the vehicle, the clearance can be reduced to the design working dimensions of the insulating barrier.

If an aerial lift insulated for the voltage involved, and the work is performed by a qualified person, the clearance (between the un-insulated portion of the aerial lift and the power line) can be reduced to the Restricted Approach Boundary given in *NFPA 70E* Table 130.4(C), column 4.

12.2 Equipment Contact

Employees standing on the ground shall not contact the vehicle or mechanical equipment or any of its attachments, unless one of the following conditions applies:

- The employee is using protective equipment rated for the voltage.
- The equipment is located so that no un-insulated part of the structure (that portion of the structure that provide a conductive path to employees on the ground) can come closer to the line than permitted in *NFPA 70 E* 130.8(F)(1).

12.3 Equipment Grounding

If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential), which can develop within a few feet or more outward from the ground point.

Chapter 13: Miscellaneous

13.1 Research and Development Laboratories

The requirements of this section shall apply to the electrical installations in those areas with custom or special electrical equipment or applications designated by the departmental management as research and development (R&D) or laboratories. Examples of these applications include low voltage–high current power systems; high voltage–low current power systems; dc power supplies; capacitors; cable trays for signal cables and other systems, such as steam, water, air, gas, or drainage; and custom-made electronic equipment.

Laboratory and R&D equipment or systems can pose unique electrical hazards that might require mitigation. Such hazards include AC and DC, low voltage and high amperage, high voltage and low current, large electromagnetic fields, induced voltages, pulsed power, multiple frequencies, and similar exposures

Therefore, each laboratory or R&D system application shall be assigned a competent person (as defined in this document) to ensure the use of appropriate electrical safety-related work practices and controls. In addition, the equipment or systems used in the R&D area or in the laboratory shall be listed or field evaluated prior to use.

13.2 Contractor Employees

Contractors' Safety and Health programs are reviewed prior to being hired by the University. Contractors are required to comply with applicable federal, state, local, and Purdue University Safety and Health rules, regulations, and guidelines. In addition, all contractors' employees must follow their company Safety and Health program rules.

Appendices

A. Regulatory References
B. Warning Labels
C. Electrical Work Hazard Assessment/Energized Work Permit Form Information and Instructions
    C-1. Electrical Work Hazard Assessment (Page 1 of 2)
    C-2. Energized Electrical Work Permit (Page 2 of 2)
D. Risk Assessment Instructions and Risk Assessment Form
E. Electrical Cord Repair Guidelines for Physical Facilities
F. Example of Electrical Safety Training Checklist

Appendix A:
Regulatory References

1. America National Standards Institute (ANSI)
2. American Society of Testing and Materials (ASTM)
3. IEEE 1584-2018, “Guide for Performing Arc Flash Hazard Calculations”
4. *NFPA 70E*, “Standard for Electrical Safety in the Workplace”, 2018 edition
5. OSHA 1910 Subpart J “General Environmental Controls”, (29 CFR 1910.147, “The Control of Hazardous Energy (Lockout/Tagout).”)
6. OSHA 1910 Subpart R “Special Industries” (29 CFR 1910.269, “Electric Power Generation, Transmission, and Distribution.”)
7. OSHA 1910 Subpart S “Electrical” (29 CFR 1910.301 – 29 CFR 1910.399)
8. Purdue University Control of Hazardous Energy (Lockout/Tagout) Program
9. Purdue University Personal Protective Equipment (PPE) Policy

Appendix B:
Arc Flash and Shock Hazard Labels

(Prior to 2015)

(2015 to Present)

Appendix C:
Electrical Work Hazard Assessment/Energized Work Permit Form Information and Instructions

INTRODUCTION

Promoting electrical safety is vital in every workplace and home.

- An average of more than 4,000 non-disabling and more than 3,600 disabling electrical contact work-related injuries are recorded annually in the United States.
- One person is electrocuted in the home every 36 hours and one person is electrocuted in the workplace every day.

The number of arc flash incidents in the United States is greater than many engineers realize since most accidents do not make the daily news. Chicago-based Capelli-Schellpfeffer, Inc. reports that five to 10 arc-flash injuries that result in hospitalization occur every day.

Severe arc-flash burns can cause a slow, painful death, but even when they are not lethal, they can do serious damage. Hot gases can injure lungs and impair breathing. Even curable burns can result in painful skin and tissue injury that can take weeks or months to heal. However, not all arc-flash injuries are physical. Psychological effects like depression, job apprehension, and family tension can also manifest themselves. Therefore, avoiding any burn is important in terms of time, money, and a person's wellbeing.

Although OSHA doesn't directly state what to do about arc-flash hazards, the personal protective equipment (PPE) standard (29 CFR 1910.132(d)(1)) requires employers to evaluate the workplace for hazards. The employer must select and require the use of appropriate personal protective equipment (PPE) for its employees based on these evaluations

Addressing the Hazard at Hand: *NFPA 70E* focus is on electrical safety and the way in which a worker plans and executes a task. When it is necessary to work on energized equipment, written work permits that include a description of the work to be done and the safety hazards involved should be issued. However, wearing the proper safety equipment for the risk hazard involved does not guarantee that a worker will remain free from injury or burns. Its purpose is to reduce deaths and life threatening burns to the chest and face areas.

Electric Hazard: Electricity-related hazards include electric shock and burns, arc-flash burns, arc-blast impacts, and falls.

- **Electric Shock and Burns:** An electric shock occurs when electric current passes through your body. This can happen when you touch an energized part. If the electric current passes across the chest or head, you can be killed. At high voltages, severe burns can result.

- **Arc-Flash Burns**: An electric arc flash can occur if a conductive object gets too close to a high-amp current source or by equipment failure (for instance, while opening or closing disconnects). The arc can heat the air to temperatures as high as 35,000° F, and vaporize metal in the equipment. The arc flash can cause severe skin burns by direct heat exposure and by igniting clothing.
- **Arc-Blast Impacts:** The heating of the air and vaporization of metal creates a pressure wave that can damage hearing and cause memory loss (from concussion) and other injuries. Flying metal parts are also a hazard.
- **Falls:** Electric shocks and arc blasts can cause falls, especially from ladders or unguarded scaffolding.

NFPA 70E **REQUIREMENTS**

Working On or Near Live Parts: Energized electrical conductor or circuit parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works within the Limited Approach Boundary of those conductors or parts.

- **Greater Hazard:** Energized work shall be permitted where the employer can demonstrate that deenergizing introduces additional or increased hazards.
- **Infeasibility:** Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a deenergized state due to equipment design or operational limitations.
- **Less Than 50 Volts:** Energized electrical conductors and circuit parts that operate at less than 50 volts to ground shall not be required to be deenergized where the capacity of the source and any overcurrent protection between the energy source and the worker are considered and it is determined that there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Informational Notes

1. *Examples of additional hazards or increased risk include, but are not limited to, interruption of life support equipment, deactivation of emergency alarm systems, and shutdown of hazardous location ventilation equipment.*
2. *Examples of work that might be performed within the Limited Approach Boundary of exposed energized electrical conductors or circuit parts because of infeasibility due to equipment design or operational limitations include performing diagnostics and testing (e.g., start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.*
3. *The occurrence of arcing fault inside an enclosure produces a variety of physical phenomena very different from a bolted fault. For example, the arc energy resulting from an arc developed in air will cause a sudden pressure increase and localized overheating. Equipment and design practices are available to minimize the energy levels and the number of at-risk procedures that require an employee to be exposed to high level energy sources. Proven designs such as arc-resistant switchgear, remote racking (insertion or removal), remote opening and closing of switching devices, high-resistance grounding of low-voltage and 5 kV (nominal) systems, current limitation, and specification of covered bus within equipment are techniques available to reduce the hazard of the system.*

Energized Electrical Work Permit: When working on energized electrical conductors or circuit parts that are not placed in an electrically safe work condition (i.e., for the reasons of increased or additional hazards or infeasibility per 130.2), work to be performed shall be considered energized electrical work and shall be performed by written permit only.

Exceptions: An energized electrical work permit shall not be required if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with this plan under any of the following conditions:

1. Testing, troubleshooting and voltage measuring
2. Thermography and visual inspections if the restricted approach boundary is not crossed
3. Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed.

FORM COMPLETION INSTRUCTIONS

Hazard Assessment for Electrical Work: This form should be filled out prior to any electrical work inside the Limited Approach or Arc Flash Boundaries. This includes testing and trouble shooting. Fill out sections 1-6 using information from Job/Work Order, arc flash label and/or *NFPA 70E* Approach Boundary, Arc Flash Category, and PPE tables. The employee performing the work shall sign and date the Hazard Assessment form.

Energized Electrical Work Permit: If an Energized Electrical Work Permit is required, complete it on the back side of the Hazard Assessment form.

Part I

This information in this section must be completed by the individual and/or department requesting the work.

Part II

Evidence of Job Briefing would include but is not limited to:

- **General:** Before starting each job, the employee in charge shall conduct a job briefing with the employees involved. The briefing shall cover such subjects as hazards associated with the job, work procedures involved, special precautions, energy source, and personal protective equipment requirements.
- **Repetitive or Similar Tasks:** If the work or operations to be performed during the work day or shift are repetitive and similar, at least one job briefing shall be conducted before the start of the first job or each day or shift. Additional job briefings shall be held if significant changes that might affect the safety of employees occur during the course of the work.
- **Routine Work:** A brief discussion shall be satisfactory if the work involved is routine and if the employee, by virtue of training and experience, can reasonably

be expected to recognize and avoid the hazards involved in the job. A more extensive discussion shall be conducted if either of the following apply:

- The work is complicated or particularly hazardous
- The employee cannot be expected to recognize and avoid the hazards involved in the job.

Agreement Work Can Be Done Safely: This requires that two electrically qualified workers agree and sign off that the energized work can performed safely. One of the signatures may be by the supervisor if electrically qualified.

Part III

Approval to Perform Electrically Energized Work: Approval requires signature of the qualified employees' supervisor. In Physical Facilities, the supervisor is required to be electrically qualified person.

Part IV

Documentation of Electrically Energized Work: Once work has been completed, the administrative supervisor (Zone Leader, Shop Supervisor, etc.) provides a signature that work has been completed. Forward a copy of the completed form to EHS/HAMP.

Appendix C-1:
Electrical Work Hazard Assessment

PURDUE UNIVERSITY | Environmental Health and Public Safety

Electrical Work Hazard Assessment

Job/Work Order Number: _____

Job Location/Circuit/Equipment: _____

Description of work to be performed: _____

1. Will this job or task require exposure to energized electrical conductors or circuit parts and/or work within an arc flash boundary (this includes testing and troubleshooting)? ☐ Yes ☐ No

2. Shock Hazard Analysis:

Voltage (V) Level Phase to Phase

☐ Less than 120 V ☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V
☐ 480 V ☐ Greater than 600 V ☐ Single phase ☐ 3 Phase

Approach Boundaries

Limited: _____ inches Restricted: _____ inches

3. Arc Flash Hazard:

Has an arc flash analysis been performed on this equipment? ☐ Yes ☐ No

- If "Yes", what is:
  - The Hazard Risk Category for the task? _____
  - The Arc Flash Boundary? _____ inches
  - Incident Energy at Working Distance? _____ cal/cm^2
- If "No", using the NFPA 70E Hazard/Risk Category Table, what is:
  - The Hazard Risk Category for the task? _____
  - The Arc Flash Boundary? _____ inches

4. Can equipment be de-energized, locked, and tagged out prior to task (other than testing/troubleshooting)? ☐ Yes ☐ No

If you answered "No" to question 4, complete the Energized Electrical Work Permit on page 2 of this document.

5. Non Electrical Hazards:

☐ Falls ☐ Chemical Exposure ☐ Traffic in Public Areas
☐ Falling Objects ☐ Biological Exposure ☐ Obstructed Egress
☐ Lack of Lighting ☐ Radiation Exposure ☐ Heavy or Repetitive Lifting
☐ Wet or Damp Area ☐ Extreme Temperature ☐ Repetitive Motions
☐ Confined Space ☐ Noise ☐ Other: _____

6. What personal protective equipment (PPE) and safety measures will be used (check all that are applicable)?

Body	☐ Arc-Rated or ☐ Cotton, Long Sleeve Shirt & Long Pants or Coveralls; ☐ Arc-Rated Rainwear or Jacket; ☐ Arc-Rated Flash Suit Jacket and Pants; ☐ Arc-Rated Fall Protection Harness			
Eye, Face, and Head	☐ Safety Glasses	☐ Safety Goggles	☐ Arc-Rated Face Shield	
	☐ Arc-Rated Hardhat	☐ Arc-Rated Balaclava	☐ Hardhat Liner	
	☐ Arc-Rated Flash Hood	☐ Hearing Protection (Ear Canal Inserts)		
Hands and Arms	☐ Heavy Duty Leather Gloves	☐ Rubber Insulating Gloves with Leather Protectors		
	☐ Rubber Insulating Gloves Only	☐ Rubber Sleeves		
Foot	☐ Closed Toe Shoes	☐ Leather Work Shoes		
Respiratory	☐ Dust Mask	☐ Air Filtering Respirator	☐ Supplied Air Respirator	☐ SCBA
Tools	☐ Insulated Tools	☐ Meter	☐ Rubber Blankets	
Safety Measures	☐ Barricades with Signs	☐ Attendant		
Other				

Employee Name _____ Employee Signature _____ Date _____

Created April 28, 2020

Page 1 of 2

Appendix C-2:
Energized Electrical Work Permit

PURDUE UNIVERSITY | Environmental Health and Public Safety

Energized Electrical Work Permit

Part I: Completed by the Requestor

Job/Work Order Number: _____

A. Description of Circuit/Equipment/Job Location:

B. Description of work to be done:

C. Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage:

Requestor's Name | Requestor's Signature | Date

Part II: Completed by the Electrically Qualified Person

A. Evidence of completion of a Job Briefing including discussion of any job-related hazards:

B. Do you agree the above-described work can be done safely? ☐ Yes ☐ No (If "No" return to requester.)

Electrically Qualified Person | Date | Electrically Qualified Person | Date

Part III: Approval(s) to Perform the Work While Electrically Energized

Approving Supervisor Name | Approving Supervisor Signature | Date

Part IV: Documentation of Electrically Energized Work

I understand that the above energized electrical work was completed on: _____
Date

Administrative Supervisor Name | Administrative Supervisor Signature

NOTE: *Forward a copy of the completed form to Radiological and Environmental Management (REM/HAMP).*

Created April 28, 2020

Page 2 of 2

Appendix D:
Hazard Risk Assessment Instructions

To perform a hazard risk assessment, use the instructions and risk rating scale (Table D.1):

1. List the task.
2. State the safety concerns, which are the possible hazards of the task.
3. If performing an assessment for an area like a shop or zone, state the number of employees performing the task. If you are filling the form out individually, leave space blank. (EHS will compile cumulative results).
4. List what existing controls are used to decrease or eliminate the hazard.
5. Then rate on a scale from 1-5 the frequency (F), how often you perform the task; likelihood of the hazard occurring (L); and the severity (S) of possible harm from the hazard. Multiply the three parameters to find the Risk rating (R).

Table D.1 – Risk Rating Scale

Rating	**Exposure Opportunity** (Frequency)	**Chance of Occurrence** (Likelihood)	**Degree of Harm** (Severity)
1	Less than 1 time per month	Highly Unlikely	First Aid
2	Less than 1 time per week	Unlikely	Medical Treatment
3	Less than 1 time per shift	Possible	Lost time, full recovery
4	Greater than 1 time per shift	Probable	Some permanent impairment
5	At all times	Highly Probable	Major permanent impairment or death

Examples of completed hazard risk assessments for testing and troubleshooting on an energized 480 volt circuit prior to and after mitigation are provides below (Table D.2 and Table D.3).

Table D.2 – Example of Risk Assessment Prior to Mitigation

Safety Concern	Exposure	Existing Controls	F	L	S	R (F*L*S)
Electrical Shock	100+ Electricians and Technicians Every Day	Only 50% PPE use observed	4	4	3	48
Arc Flash	100+ Electricians and Technicians Every Day	Only 50% PPE use observed	4	2	5	40

Table D.3 – Example of Risk Assessment After Mitigation

Safety Concern	Exposure	Existing Controls	F	L	S	R (F*L*S)
Electrical Shock	100+ Electricians and Technicians Every Day	Increased observed PPE use to 99% after training and increased supervision	4	1	1	4
Arc Flash	100+ Electricians and Technicians Every Day	Increased observed PPE use to 99% after training and increased supervision	4	2	2	16

Appendix D-1:
Hazard Risk Assessment Form

PURDUE UNIVERSITY
Electrical Safety Program

Hazard Risk Assessment

TASK:_____

Safety Concern	Exposure	Existing Controls	F	L	S	R (F*L*S)

Completed by (Print) **Signature** **Date**

To perform a hazard risk assessment, use the instructions and risk rating scale (Table D.1):

1. List the task.
2. State the safety concerns, which are the possible hazards of the task.
3. If performing an assessment for an area like a shop or zone, state the number of employees performing the task. If you are filling the form out individually, leave space blank. (REM will compile cumulative results).
4. List what existing controls are used to decrease or eliminate the hazard.
5. Then rate on a scale from 1-5 the frequency (F), how often you perform the task; likelihood of the hazard occurring (L); and the severity (S) of possible harm from the hazard. Multiply the three parameters to find the Risk rating (R).

Table D.1 – Risk Rating Scale

Rating	Exposure Opportunity (Frequency)	Chance of Occurrence (Likelihood)	Degree of Harm (Severity)
1	Less than 1x per month	Highly Unlikely	First Aid
2	Less than 1x per week	Unlikely	Medical Treatment
3	Less than 1x per shift	Possible	Lost time, full recovery
4	Greater than 1x per shift	Probable	Some permanent impairment
5	At all times	Highly Probable	Major permanent impairment or death

The *Electrical Safety Program* has example hazard risk assessments (Table D.2 and Table D.3) in Appendix D.

Revised: January 10, 2014

Appendix E:
Electrical Cord Repair Guidelines for Physical Facilities

- ***All cord repairs should be done by Tool Crib or Equipment Repair Shop personnel, not other shops or zone employees***

- ***One shrink wrap repair per cord. The cord would be replaced on the second repair***

- ***Shrink wrap should cover no greater than 12 inches of cord***

- ***Cord must retain its original flexibility after the repair***

- ***If the inner conductor insulation is compromised, the cord will be replaced***

- ***Replacement cord will be of the same gauge or larger.***

- ***No repairs to cords used on floor scrubbers, wet vacuums or other equipment used in wet conditions.***

Appendix F:
Example Electrical Safety Training Checklist

ELECTRICAL SAFETY TRAINING CHECKLIST			
TRAINING ITEM	**YES** ☑	**N/A** ☑	**COMMENTS**
SCOPE AND TRAINING			
1. All employees who work on, near or with premises wiring, wiring for connections to supply, other wiring, and installation of optical fiber cable along with electrical conductors have been trained as either qualified or unqualified workers.	❑	❑	
2. Unqualified person have been trained in and are familiar with any electrically related safety practices not covered by this standard but necessary for their safety.	❑	❑	
3. Qualified persons trained in and familiar with:			
a) Skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.	❑	❑	
b) Voltage determination.	❑	❑	
c) Clearance distances that must be maintained.	❑	❑	
d) Training conducted has been specific to the hazards to which the employee may or will be exposed and their particular job duties.	❑	❑	
SELECTION AND USE OF WORK PRACTICES			
1. Work practices used to prevent electric shock and other injuries address de-energized parts that may be energized.	❑	❑	
2. Work practices used to prevent electric shock and other injuries address exposure to energized parts.	❑	❑	
3. Procedure provided for work on or near exposed de-energized parts includes:			
a) Written procedures specific to the equipment or worksite.	❑	❑	
b) De-energizing equipment.	❑	❑	
c) Application of locks and tags.	❑	❑	
4. Working on or near exposed energized parts:			
a) All employees near enough to be exposed to a hazard have been trained, and are aware of the practices that must be followed to protect them from the hazard.	❑	❑	
b) Only qualified employees work on energized parts.	❑	❑	
c) Overhead lines de-energized and grounded prior to working near them or other protective measures used.	❑	❑	
d) Unqualified persons working near overhead lines are aware that they may not come approach, or use conductive objects closer than, 10 feet for lines up to 50 kV, or 10 feet plus 4 inches for every 10 kV over 50 kV.	❑	❑	
e) Qualified persons have a working knowledge of the allowable approach distances of this program.	❑	❑	
f) Vehicle and mechanical equipment operators understand that they must maintain:			
i) A clear distance of 10 feet plus 4 inches for every 10 kV over 50 kV while working near energized overhead lines.	❑	❑	
ii) A clear distance of 4 feet plus 4 inches for every 10 kV over 50 kV while in transit.	❑	❑	
iii) Insulating barriers are used and installed as required.	❑	❑	
iv) Insulated aerial lift operated by a qualified person must comply with the separation distances.	❑	❑	
v) Employees standing on the ground understand they may not contact the vehicle unless using protective equipment rated for the voltage or the equipment located so no un-insulated part can provide a conductive path to persons on the ground.	❑	❑	
g) Illumination is provided at all worksites to assure safe work.	❑	❑	
h) Protective shields and barriers provided and used for work in confined spaces to prevent contact with exposed energized parts.	❑	❑	
i) All conductive materials such as pipes, rods, etc. are handled so as to prevent contact with exposed energized parts.	❑	❑	
j) Conductive articles of clothing and jewelry such as watches, rings, etc. are not worn if they might contact exposed energized parts unless rendered nonconductive.	❑	❑	
k) Portable ladders with nonconductive side rails are used when working near or on exposed energized conductors.	❑	❑	
l) Housekeeping conducted only when exposed energized parts may not be contacted. Barriers provided and nonconductive cleaning materials used.	❑	❑	
m) Only qualified persons are allowed to defeat electrical interlocks on temporary basis while they work on equipment.	❑	❑	

Page **1** of **2**

ELECTRICAL SAFETY TRAINING CHECKLIST			
TRAINING ITEM	**YES ☑**	**N/A ☑**	**COMMENTS**
USE OF EQUIPMENT			
1. Portable electric equipment such as cord-and-plug connected equipment, including flexible cords:			
a) Handled in a manner to avoid damage.	❑	❑	
b) Not used to raise or lower equipment.	❑	❑	
c) Not fastened with staples or hung so as to damage insulation.	❑	❑	
d) Visually inspected before each use on each shift.	❑	❑	
e) Defective items removed from service and not used until rendered safe.	❑	❑	
f) Plugs and receptacles mate properly.	❑	❑	
g) Flexible grounding-type cords have a grounding conductor.	❑	❑	
h) Grounding plug not defeated.	❑	❑	
i) Adapters that interrupt grounding continuity not used.	❑	❑	
j) Approved equipment used for work in conductive work locations (e.g. wet locations, etc.).	❑	❑	
k) Locking-type connectors are properly secured after connection.	❑	❑	
ELECTRIC POWER AND LIGHTING CIRCUITS			
1. Only load rated switches or circuit breakers used as disconnecting means.	❑	❑	
2. Circuits not manually reenergized until it is determined that it is safe to do so.	❑	❑	
3. Overcurrent protection of circuits not modified.	❑	❑	
TEST INSTRUMENTS AND EQUIPMENT			
1. Used by qualified persons only.	❑	❑	
2. Visually inspected before use.	❑	❑	
3. If circuit tested is over 600 volts, nominal, test instrument tested for proper operation before and immediately after the test.	❑	❑	
4. Test instrument rated for the circuit to be tested and appropriate for the environment.	❑	❑	
5. Electrical equipment capable of igniting flammable or ignitable materials not used if present in the worksite.	❑	❑	
SAFEGUARDS FOR PERSONNEL PROTECTION			
1. Protective equipment used when there is exposure to potential electrical hazards.	❑	❑	
2. Protective equipment maintained in safe and reliable condition and tested and inspected as required.	❑	❑	
3. Protective equipment protected from damage during use.	❑	❑	
4. Approved electrically rated hardhats used as needed to protect head from electric shock or burns.	❑	❑	
5. Safety glasses or goggles used as needed to protect eyes or face when there is a danger of arcs, flashes or flying objects.	❑	❑	
6. Approved gloves worn that are appropriate for the hazard present	❑	❑	
7. Insulated tools or handling equipment used when conductors may be contacted.	❑	❑	
8. Insulated fuse handling equipment used to remove or install fuses when terminals are energized.	❑	❑	
9. Ropes and hand lines used near energized parts are nonconductive and are protected from moisture.	❑	❑	
10. Protective shields, barriers or insulating materials are used to protect employees working near exposed energized parts.	❑	❑	
ALERTING TECHNIQUES			
1. Safety signs and tags used when necessary to warn employees about electrical hazards.	❑	❑	
2. Barricades used with safety signs when necessary to prevent or limit employee access to work areas with un-insulated energized conductors or parts.	❑	❑	
3. Attendants stationed as needed to warn when signs or barricades are not sufficient to prevent unauthorized access.	❑	❑	
TRAINER:	**DATE:**		
EMPLOYEE NAMES			

Appendix G:
Summary of Changes

July 16, 2024

- Changed *"Radiological and Environmental Management"* and *"REM"* references to *"Environmental Health and Safety"* and *"EHS"* respectively
- Corrected formatting, punctuation, and spelling