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	Approved By: Avraham Boruchowitz, CSP, CHMM

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Founding Principle

This Electrical Safety Program is founded on the principle of avoiding energized work unless it is absolutely necessary. Live parts will be de-energized before an employee works on or near them unless one of the following conditions apply:

- De-energizing introduces additional or increased hazards.
- De-energizing is not possible due to equipment design or operations limitations.
- Live parts are operating at less than 50 volts to ground and there is not increased exposure to electrical burns or to explosion due to electrical arcs.

1.0 Purpose & Introduction

More than 3,600 disabling electrical injuries occur in the workplace and more than 2,000 workers are sent to burn centers with electric burns every year in the United States. Every day one person dies from electrical incidents. Most incidents and injuries related to electrical systems can be avoided by following safe work practices. Besides the personal pain of suffering an injury, incidents can result in lost time, medical costs, equipment damage, production loss, and legal costs.

Radford University is committed to provide a safe work environment for its employees and contractors performing electrical work. This program was developed to assure that University employees understand and comply with the regulatory requirements related to electrical work; assure safety of employees who may work in the vicinity of, or on, electrical systems; and assure that all departments that perform electrical work on campus follow uniform work practices and regulatory requirements. (Lockout/Tagout is briefly addressed in this program, specific requirements for Lockout/Tagout are found in EHS Document OCS-201, the Hazardous Energies Control and Lockout/Tagout Program.)

This program does not serve as a method to qualify persons. The program incorporates requirements of the Occupational Health and Safety Administration's (OSHA) Electrical Standard (29 CFR 1910), and serves as the Electrical Safety Program in accordance with the standard. This electrical safety program is designed to minimize, and in some instances eliminate, the hazards associated with electrical work. It establishes minimum standards to prevent hazardous electrical exposures to personnel, and to ensure compliance with regulatory requirements.

In order to maximize safety, working on equipment in a de-energized state is **required** unless de-energizing introduces an increased hazard (e.g. deactivation of emergency alarm systems or

shutdown of hazardous location ventilation systems) or it is not possible to complete *critical work* due to equipment design or operational limitations (e.g. testing of electrical circuits that can only be performed with the circuit energized).

For work to proceed on energized equipment (at 50 volts or greater), approval must be obtained via the Energized Electrical Work Permit from the supervisor, the Manager of Electrical Services, the Director of Environmental Health and Safety (or his/her designee), and the Director of Facilities Management (or his/her designee), see Appendix B; If an electrical system cannot be de-energized and a permit has been approved, then only qualified personnel as specified under 29 CFR 1910, Subpart S, will work on the system using appropriate personal protective equipment (PPE) as specified in this program and under NFPA 70E.

The program has been developed to help employees and departments comply with recognized safety practices:

- Provide and demonstrate a safety program with defined responsibilities.
- Determine the degree of arc flash hazard by qualified personnel.
- Affix warning labels on equipment.
- Provide PPE for workers.
- Provide documented training.
- Provide appropriate tools for safe work.

The overall effectiveness of this program shall be assessed by Environmental Health and Safety (EHS) at least annually.

2.0 Scope

This program applies to all Radford University properties and work performed by its employees regardless of job site location. All employees who face a risk of electrical shock, burns, or related injuries must be trained in electrical safe work practices. It is imperative that, at a minimum, these guidelines be met or exceeded to enhance employee safety. In addition, employees that work around, but not on, electrical systems must be trained in the inherent danger of electricity. This Electrical Safety Program describes work practices for both *qualified* and *unqualified* persons. This program also covers academic and research activities requiring work on or diagnosis of any energized electrical systems. Safe-work practices beyond the scope of this program must be established for each work area by responsible qualified persons and at minimum must include the safety concerns and procedures outlined by this program.

Each department that performs work covered by this program must designate one or more employee(s) to assist in coordination of the requirements of this program at the department levels. Furthermore, it is recommended that each supervisor that oversees work covered by this program be designated to coordinate this program in their work area. These coordinators will assist EHS with identifying training departmental members that work on or near electrical systems and they will review and verify the skills and competency of their coworkers.

This document provides the minimum safety knowledge and procedures that will allow individuals, departments, and facilities to work with, or in near proximity to, energized high and low voltage sources ("working on" or "working near" live parts). However, each individual, department, or facility shall be responsible for the details and activities specific to the affected facility or department.

If there are local governmental codes, accepted employee safety standards, design criteria, etc., that are more stringent than those identified in this program, then those shall be considered more appropriate, and shall be followed. This program is in accordance with OSHA standard 29 CFR 1910.331 through 1910.335.

Knowledge of this program does not make a person a qualified electrical worker. Guidelines for determination of a qualified employee shall be established by management concerning informal and formal training, as well as levels of experience needed for workers in the electrical field or other workers whose job function would expose them to a potential electrical hazard.

3.0 Definitions

Accessible (Readily Accessible) – Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc.

AFC – Arc Fault Current, the calculated maximum incident amperage available as a result of an arc fault condition.

Affected and Other Employee – Any employee in an office or industrial setting who works around outlets, electrical panels, or electrical switches, and whose job requires them to be near or around the hazard zone (but not within the hazard zone) when equipment is being serviced or maintained under a locked-out or tagged-out condition. For example, a machine operator that must stay near the machine during a lock out is classified as an Affected Employee. Office staff working on computers and electrical equipment when nearby equipment is being serviced or maintained during a lockout are also classified as Affected Employees. The Affected Employee

must be instructed never to attempt to restart or reactivate equipment that is locked out or tagged out.

Apparatus – A term used in this document to denote tools, appliances, machines, equipment, and piping systems that utilize or produce energy.

Approach Boundary – The distances to an exposed, energized electrical part or circuit.

Arc-Flash Boundary – An approach limit distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur.

Arc-Flash Burns – Occur if a conductive object gets too close to a high-amp current source or by equipment failure (e.g. while opening or closing disconnects). The arc can heat the air to temperatures as high as 35,000 °F, and can vaporize metal in the equipment. The arc flash can cause severe skin burns by direct heat exposure and by igniting clothing.

Arc Rating – The maximum incident energy resistance demonstrated by a material (or layered system of materials) prior to break open or at the onset of a second-degree skin burn. Arc rating is normally expressed in cal/cm^2.

Bolted Fault Current – The calculated highest fault current as a result of a direct short circuit.

Break Open – A material response evidenced by the formation of one or more holes in the innermost layer of flame-resistant material that would allow flame to pass through the material.

Confined Space – An enclosed space not intended for continuous occupancy which has limited egress and access. It becomes a Permit Required Confined Space if there is an atmospheric hazard (e.g. explosive atmosphere or asphyxiating hazard) and/or other serious safety hazards (e.g. electrical hazard).

Damp Location – Partially protected locations subject to moderate degrees of moisture, such as some basements.

Dead Front – Without live parts exposed to a person on the operating side of the equipment.

De-energized Electrical Work – Electrical work that is performed on equipment that has been previously energized and is now free from any electrical connection to a source of potential difference and from electrical charges.

Disconnecting Means – The switch or device used to disconnect the circuit from the power source.

Dry Location – Locations not normally subject to dampness or wetness, as in the case of a building under construction.

Electrical Hazard – A recognizably dangerous condition such as exposed energized parts or unguarded electrical equipment that is energized or may unexpectedly become energized which can result in electrical shock, arc flash burn, thermal burn, or blast.

Electric Shock and Burns – Occurs when electric current passes through the body. This can happen when touching an energized part. If the electric current passes across the chest or head, death can result.

Energized Electrical Work – Repair, maintenance, troubleshooting, or testing on electrical circuits, components, or systems while energized (i.e. live). Only Qualified Employees are permitted to work on energized circuitry of 50 volts/25 amps to ground or greater.

Exposed – Terminals, conductors, or equipment, not shielded or guarded from contact. Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated.

Falls – Electrical shocks and arc blasts can cause falls, especially from ladders or unguarded scaffolding.

Fault-Clearing Time – The timing required to for the nearest circuit protective device (e.g. circuit breaker or fuse) to operate to clear a fault, typically in milliseconds.

Feeder – All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit over-current device.

Flame-Resistant (FR) – The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source.

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

Flash Hazard Analysis – A study investigating a worker's potential exposure to arc-flash energy, conducted for the purpose of injury prevention and the determination of safe work practices and the appropriate levels of PPE.

Flash Suit – A complete flame-resistant clothing and equipment system that covers the entire body, except for the hands and feet.

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.

Grounded, Effectively – Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazards to connected equipment or to persons.

Ground Fault Circuit Interrupt (GFCI) – A device whose function is to interrupt the electric circuit to the load when a fault current to ground exceeds a predetermined value.

Guarding or Shielding – Nonconductive shields installed in electrical cabinets/boxes over hazardous voltage components that could be inadvertently contacted during electrical work.

Hazardous Voltage – Voltages in excess of 50 volts or capable of releasing high energies causing arcs and or arc blasts.

High Voltage – Voltages including and above 600 volts.

Hot Stick – An insulated live-line tool that allows a qualified person to manipulate switches, fuses, or other electrical devices while still allowing safe minimum approach distances.

Inadvertent Contact – Any unintentional contact with hazardous voltage because of work in close proximity to energized components.

Incident Energy – The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.

Isolated (as applied to a location) – Not readily accessible to persons unless special means for access are used.

Isolating Switch (or Disconnecting Switch) – A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and is intended to operate only after the circuit has been opened by some other means.

Life Safety Equipment – Equipment that provides critical protection for safety in the event of an emergency or other serious hazard. Life safety equipment, which is electrically energized, should be worked on using energized electrical equipment procedures to ensure that the protection provided by the equipment is not lost (e.g. fire alarm and evacuation).

Limited Approach Boundary – A boundary around exposed live parts that may not be crossed by an unqualified person unless accompanied by a qualified person.

Lockout/Tagout (LOTO) – Refers to a specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance.

Low Voltage System – Associated electrical conductors and equipment subject or capable of operating under relative low voltage, for the purposes of this program, 0 to 50 volts.

Non-qualified Person – The same as an Unqualified Person. This is a non-OSHA term sometimes used in place of unqualified.

On-The-Job-Training (OJT) – An employee undergoing on-the-job training who has demonstrated the 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 purposes of those duties.

Prohibited Approach Boundary – The area near exposed live parts that may be crossed only by qualified persons using the same protection as if direct contact with live parts were planned. This is defined by the nominal voltage.

Qualified Person – (synonyms: qualified worker, qualified employee) A qualified person trained and knowledgeable of construction and operation of equipment or a specific work method and is trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Qualified persons must be certified by their managers or supervisors, complete the proper training requirements, be capable of working safely on energized circuits and shall be familiar with proper use of special precautionary techniques, personal protective equipment, insulating/shielding material, and insulated tools. Certification shall be based on training, experience, and knowledge of the electrical hazards involved with the work being performed.

- Qualified Persons shall be familiar with the proper use of the special precautionary techniques, personal protective equipment (PPE), including arc-flash, insulating and shielding materials, and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but unqualified for others.
- An employee who is undergoing on-the-job training and who, in the course of such training, has performed duties safely at his or her level of training and who is under the direct supervision of a qualified person shall be considered to be qualified.
- Only a Qualified Person is allowed to work on energized circuits.
- Qualified Persons shall not be assigned to work alone, except for replacing fuses, operating switches, or other operations that do not require the employee to contact energized high voltage conductors or energized parts of equipment, clearing trouble, or emergencies involving hazard(s) to life or property.
- A person may be qualified to work, for example, on circuits up to 600 volts, but may be unqualified to work on higher voltages.

Restricted Boundary Approach – An approach limit distance from an exposed live part within which there is an increased risk of shock, due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to the live part. It may only be crossed by qualified persons using appropriate shock prevention techniques and equipment.

Service – The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

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.

Short Circuit Current – The maximum electrical current which can flow in a particular electrical system under short circuit conditions.

Standby Personnel – Designated employee meeting the following qualifications, and within sight or calling distance of "qualified" employee working on exposed high voltages:

- Familiarity with the means of removing power from the equipment or circuit;
- Familiarity with the notification procedures to summon emergency personnel.

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.

Servicing and/or Maintenance – Workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, troubleshooting, and maintaining and/or servicing of machinery or equipment. These activities include lubrication, cleaning or unjamming of machines or equipment, and making adjustments or tool changes where the employee may be exposed to the unexpected energization or startup of the equipment or release of hazardous energy.

Stored Energy Source – Any device that is capable of holding energy after equipment shutdown. This includes, but is not limited to, capacitors, tanks, pipes, springs, and flywheels.

Tagout – The placement of a tagout device on an energy-isolating device in accordance with established written procedures to control hazardous energy. Using tagout as a form of hazardous energy control is not a positive means of controlling hazardous energy and shall not be used whenever lockout is possible.

Tagout Device – A prominent warning tag capable of being securely attached that provides a warning not to use the equipment. The tag should include: reason for tag, name of person placing the tag and how that person may be contacted, and the date the tag was placed. Tags must be durable and able to withstand the environment to which they are exposed for the maximum time exposure is expected. Tags must include a legend such as: Do Not Start; Do Not Operate; Do Not Close; Do Not Energize; or Do Not Open. Tags must be legible and understandable. These tags shall not be used for other purposes.

Unqualified Person – Person not familiar with the construction and operation of the equipment and the hazards involved. Those with little or no training.

Voltage – The greatest room-mean-square (effective) difference of potential between any two conductors of the circuit connected.

Voltage, Low – Circuits with a nominal voltage less than or equal to 50 volts.

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).

4.0 Responsibilities

Supervisor/Manager Responsibilities (Facilities Management/Department)

- Promote electrical safety awareness to all employees.
- Evaluate work being performed and determine compliance with this program.
- Ensure employees comply with all provisions of the Electrical Safety Program.

- Ensure employee receive training appropriate to their assigned electrical tasks and maintain documentation of such training.
- Develop and maintain a listing of all qualified employees under their supervision.
- Ensure employees are provided with, and use, appropriate personal protective equipment (PPE).

Employees (Qualified Electrical Workers)

- Follow the work practices described in this program, including the use of appropriate PPE and tools.
- Attend all training required by this program and your supervisor.
- Immediately report any concerns related to electrical safety to supervision.
- Do not perform any electrical work without proper training and equipment.
- **Employees are also encouraged to work with safety always in mind, and to exercise their right to stop any work that poses a danger to life and property.**

Environmental Health and Safety (EHS)

EHS is responsible for developing, implementing, and administering the Electrical Safety Program. These responsibilities include:

- Evaluate work being performed and determine compliance with this program.
- Provide or assist in the task of specific training for electrical work qualifications.
- Maintenance of training records.
- Periodically review and update this written program.
- Provide or coordinate general training on the content of this program.
- Evaluate the overall effectiveness of the program at least annually.
- Assist departments in the implementation of this program.

Facilities Planning and Construction

- Complete arc flash analyses and appropriate labeling required by this program during equipment replacement, upgrading, or construction of new facilities.
- Place an emphasis on controlling electrical hazards through the application of engineering and design controls.
- Promote consistency in electrical installations throughout the various facilities.

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5.0 Program Components

All activities must be conducted in accordance with the applicable parts of the Occupational Safety and Health Administration (OSHA) 1910 Subpart S – Electrical for General Industry and, where applicable, 1926 Subpart K – Electrical for Construction.

5.1 – Electrical Safety Principles – Energized Condition

- **De-energize whenever possible.**
- **Plan every job.** The approach and step-by-step procedures to complete the work at hand must be discussed and agreed upon between all involved employees at the beginning. Write down first-time procedures. Discuss hazard and procedures in a job briefing with supervisors and other workers before starting any job. Use a checklist system for working on live circuits, if such a scenario arises.
- **Identify the hazards.** Conduct an electrical hazard risk assessment. Identify steps that could create electric shock or arc-flash hazards.
- **Minimize the hazards.** De-energize any equipment, and insulate, or isolate, exposed live parts so contact cannot be made. If this is impossible, obtain and wear proper PPE and tools.
- **Anticipate problems.** If it can go wrong, it might. Make sure the proper PPE and tools are immediately available for the worst-case scenario.
- **Obtain training.** Make sure all involved employees are a qualified electrical worker with appropriate training for the job.

5.2 – Portable Electrical Equipment and Extension Cords

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

- Extension cords may only be used to provide temporary power. Extension cords are considered to be temporary wiring, and must also comply with Section 5.3, Temporary Wiring.
- Portable cord-and-plug-connected equipment and extension cords must be visually inspected before each use on any shift for external defects such as loose parts, deformed and missing pins, or damage to outer jacket or insulation, and for possible internal damage such as pinched or crushed outer jacket. Any defective or damaged cord or cord-and-plug-connected equipment must be removed from service and must be immediately discarded, or tagged and repaired by a qualified person.

- Extension cords must be of the three-wire type. Extension cords and flexible cords must be designed for hard or extra hard usage (e.g. types S, ST, and SO). The rating approval must also be visible.
- Job-made extension cords are forbidden per the electrical code.
- Personnel performing work on renovation or new construction sites using extension cords, or where work is performed in damp or wet locations, must be provided, and must use, a ground-fault circuit interrupter (GFCI).
- Portable equipment must be handled in a manner that will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.
- Extension cords must be protected from damage. Sharp corners and projections must be avoided. Flexible cords may not be run through windows or doors unless protected from damage, and then only on a temporary basis. Flexible cords may not be run above ceilings, or 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.
- Cords must be covered by a cord protector or tape when they extend into a walkway or other path of travel to avoid creating a trip hazard.
- Extension cords used with grounding-type equipment must contain an equipment-grounding conductor (i.e. the cord must accept a three prong, or grounded plug).
- Attachment plugs and receptacles may not be connected or altered in any way that would interrupt the continuity of the equipment-grounding conductor. Additionally, these devices may not be altered to allow the grounding pole to be inserted into current connector slots. Clipping the grounding prong from an electrical plug is prohibited.
- Flexible cords may only be plugged into grounded receptacles. The continuity of the ground in a two-prong outlet must be verified before use. If an ungrounded receptacle is identified, it shall be reported to the Manager of Electrical Services, or their designee, for corrective action.
- Adapters that interrupt the continuity of the equipment grounding connection may not be used.
- All portable electric equipment and flexible cords used in highly conductive work locations, such as those with water or other conductive liquids, or in places where employees are likely to contact water or conductive liquids, must be National Recognized Test Laboratories (NRTL) approved equipment and approved for those locations.
- Employee's hands must be dry when plugging and unplugging flexible cords and cord-and-plug connected equipment if energized equipment is involved.
- If the connection could provide a conducting path to employees hands (e.g. if a cord connector is wet from being immersed in water), the energized plug and receptacle connections must be handled only with insulating protective equipment.

- Locking type connectors must be protected from breakage, and metal shell sockets must be grounded.
- Temporary lights must not be suspended by their cords unless they have been designed for this purpose.
- Portable lighting used in wet or conductive locations, such as tanks or boilers, must be operated at no more than 12 volts or must be protected by GFCIs.
- Extension cords are considered to be temporary wiring, and must also comply with Section 5.3 of this program.

5.3 – Temporary Wiring

Temporary electrical power and lighting installations of 600 volts or less, including flexible cords, cables, and extension cords, may only be used during and for renovation, maintenance, repair, or experimental work. The duration for temporary wiring used for decorative lighting for special event and similar purposes may not exceed 90 days. The following additional requirements apply:

- Ground-fault protection (or GFCI) must be provided on all temporary-wiring circuits, including extension cords, used on construction sites.
- In general, all equipment and tools connected by cord-and-plug must be grounded. Double-insulated tools and appliances with two-prong plugs are acceptable.
- Feeders must originated in an approved distribution center, such as a panel board, that is rated for the voltages and currents the system is expected to carry.
- Branch circuits must originate in an approved power outlet or panel board.
- Neither bare conductors nor single wire earth returns may be used for the wiring of any temporary circuit.
- Receptacle must be of the grounding type. Unless installed in a completed metallic raceway, each branch circuit must contain a separate equipment-grounding conductor, and all receptacles must be electrically connected to the grounding conductor.
- Flexible cords and cables must be of an approved type and suitable for the location and intended use. They may only be used for pendants, wiring of fixtures, connection of portable lamps or appliances, elevators, hoists, connection of stationary equipment where frequently interchanged, prevention of transmission of noise or vibration, data processing cables, or where needed to permit maintenance or repair. They may not be used as a substitute for fixed wiring, run through holes in walls, ceilings or floors, run through doorways, windows or similar openings, attached to building surfaces, or concealed behind walls, ceilings or floors.
- Suitable disconnecting switches or plug connects must be installed.

- Lamps for general illumination must be protected from accidental contact or damage, either by elevating the fixture or by providing a suitable guard. Hand lamps supplied by flexible cords must be equipped with a handle of molded composition or other approved material, and must be equipped with a substantial bulb guard.
- Flexible cords and cables must be protected from accidental damage. Sharp corners and projections are to be avoided. Flexible cords and cables must be protected from damage when they pass through doorways or other pinch points.
- **Extension cords or devices identified as Multi-Outlet Strips or Temporary Power Taps may not be used as a substitute for fixed wiring.**
- Relocatable Power Taps or multi-plug receptacles may be used in offices and labs to provide electrical power to electronic equipment, such as personal computers, if they are used to reduce line noise or to provide surge or over-current protection and provided the combined load does not exceed the rating of the circuit, the taps are listed and are equipped with circuit protection that does not exceed the rating of the power source or outlet nor be modified or used in combination; that is to plug one into another ("daisy-chained"). When used, these devices must be located so that they are not susceptible to damage and are easily accessible. Power taps are not to be used inside equipment unless they are specifically listed, approved, and designed by the manufacturer for that use.

5.4 – Wet Areas

Work in wet or damp work locations (i.e. areas surrounded or near water or other liquids) should not be performed unless it is absolutely critical. Electrical work should be postponed until the liquid can be cleaned up. The following special precautions must be incorporated while performing work in damp locations:

- Only use electrical cords that have GFCIs.
- Place a dry barrier over any wet or damp work surface.
- Do not work in areas where there is standing water.
- Remove standing water before beginning work.
- Do not use electrical extension cords in wet or damp locations.
- Keep electrical cords away from standing water.

5.5 – Labeling of Disconnects

Each disconnecting means – the switch or device used to disconnect the circuit from the power source must be clearly labeled to indicate the circuit's function, unless it is located and arranged so the purpose is evident. Identification should be specific rather than general. For example, a branch circuit serving receptacles in a main office should be labeled as such, not simply labeled

"receptacles." All labels and marking must be durable enough to withstand the environment to which they may be exposed.

- Energy from more than one source – motors and motor operated equipment with more than one source of power may have multiple disconnects. Where multiple *disconnecting means* are provided, a permanent warning sign shall be provided on or adjacent to each *disconnecting means*.

5.6 – Working on De-Energized Equipment

Electrically Safe Condition

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 them. Proper PPE must be worn until the equipment is proven to be de-energized:

- Voltage rated gloves and leather protectors must be worn.
- Electrically insulated shoes should be worn.
- Approved insulating mats must be used.
- Safety glasses must be worn.
- The required Arc Flash PPE must also be worn.

The National Fire Protection Agency (NFPA) lists six steps to ensure conditions for electrically safe work:

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 draw-out type circuit breakers are fully withdrawn.
4. Apply lockout/tagout devices in accordance with the formal, written procedure for the equipment and OCS-201 "Hazardous Energies Control and Lockout/Tagout Program".
5. Test each phase conductor or circuit part with an adequately rated voltage detector to verify that 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 be sure 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.

The process of de-energizing is "live" work and can result in an arc flash due to equipment failure. When de-energizing, follow the procedures described in section 5.10, "Working On or Near Energized Equipment."

Lockout/Tagout Program

All electrical workers will be trained on, and follow the requirements of the University's Hazardous Energies Control and Lockout/Tagout Program (OCS-201). This is a prerequisite for any electrical work.

Re-energizing Equipment

In addition to the requirements of the Lockout/Tagout Program (OCS-201), the following requirements must be met, in the order given, before circuits or equipment are re-energized, even temporarily:

1. A qualified person must conduct tests and visual inspections as necessary to verify that all tools, electrical jumpers, shorts, grounds, and other such devices have been removed so that circuits and equipment can be safely energized.
2. Employees potentially exposed to the hazards of re-energizing of the circuit must be warned to stay clear.
3. Each employee removes his or her lock(s) and tag(s).

5.7 – Work within Boundaries of Overhead Lines

- Work shall conform to NFPA 70E, Article 130.8.
- No university personnel shall use vehicular or mechanical equipment (e.g. portable lifts, dump trucks, and bucket trucks) at minimum within 10 feet of overhead transmission, distribution, or power substation.
- The minimum clearance of 10 feet must be maintained between energized overhead lines and all vehicles or equipment capable of having parts or its structure elevated.
- If the voltage of the overhead line is greater than 50 kV, the clearance must be increased by 4 inches for every 10 kV over 50 kV.
- A spotter must be used at all times.

5.8 – Underground Electrical Lines and Equipment

- Work shall conform to NFPA 70E, Article 130.9.
- Whenever burial of electrical lines takes place, detectable underground warning tape shall be buried above the electric line to provide easy detection and proximity warning for future excavations.
- Whenever energized lines are exposed in excavations, *qualified persons* shall establish boundaries (i.e. plastic red barrier tape stating "DANGER – Do Not Enter") as a first priority to prevent *unqualified persons* from entering the restricted area.
- If during excavation, an electric line is cut or damaged, excavation work shall stop and a *qualified person* shall be called to the site to secure the line and determine if the excavation can safely continue.

5.9 – Cutting and Drilling

- Work shall conform to NFPA 70E, Article 130.10.

5.10 – Working On or Near Energized Electrical Equipment

Working on live circuits means actually touching energized parts, while working near live circuits means working close enough to energized parts to pose a risk even though work is done on de-energized parts. Common tasks where there may be a need to work on or near live circuits include:

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

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). **It is imperative that workers ensure that only one hand is in contact with the equipment.**

5.11 – Energized Electrical Work Permit **(50 Volts or Higher)**

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 explosion due to electrical arcs, however, it is

encouraged that work be done in a de-energized state if that work can be performed more safely than in an energized state.

Work related to testing, troubleshooting, and voltage measuring may be completed by a qualified persons without a permit provided appropriate safe work practices and PPE are used. If live parts are not placed in an electrically safe condition, work to be performed shall be considered energized electrical work. Other than those tasks listed in Section 5.8 above, energized work shall not be permitted unless one of the following conditions exists:

1. It can be demonstrated that de-energizing introduces additional or increased hazards or;
2. De-energizing is infeasible due to equipment design or operational limitations.

If either of the above two conditions exist, and energized electrical work is necessary, a written Energized Electrical Work Permit (see Appendix B) must be generated that addresses and includes the following:

- Description of the work to be performed.
- Justification for the work.
- List of all safety precautions to be taken prior to, and during, the energized electrical work.
- Proper PPE to be worn.
- Results of shock and flash hazard analysis.
- Evidence of completion of a job safety briefing.
- Signatures of the qualified electrician(s) who will be performing the work, their supervisor, their department manager/director, the University Electrical Safety Manager, the Director of EHS (or his/her designee), and the Director of Facilities Management (or his/her designee). **All signatures are required for the permit to be valid.**
- **The completed Energized Electrical Work Permit shall be on-site during energized electrical work** and maintained on file in the department office of the department performing, or overseeing, the work.
- **Exception:** When Energized Electrical Work is required on a construction site turned over to and controlled by a General Contractor (GC) utilizing non-University employees, the GC is responsible for ensuring that the work can be accomplished safely in accordance with the OSHA Construction Rule 1926.416(a)(1) and any other applicable regulations.

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5.12 – Approach Distances to Exposed Live Parts

The National Fire Protection Association (NFPA) defines three approach distances for shock hazards and one for arc flash.

- The **Limited Approach Boundary** is the distance from an exposed live part within which a shock hazard exists.
- The **Restricted Approach Boundary** is the closest distance to exposed live parts a qualified person can approach without proper PPE and tools. 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. Have an energized work permit that has been fully approved.
    2. Use PPE suitable for working near exposed live parts and rated for the voltage and energy level involved.
    3. Be certain that no part of the body enters the prohibited space.
    4. Minimize the risk 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.
- The **Prohibited Approach Boundary** is the minimum approach distance to exposed live parts to prevent flashover or arcing. Approaching any closer is comparable to making direct contact with a live part. To cross the Prohibited Approach Boundary, the qualified person must:
    1. Have specified training to work on exposed live parts.
    2. Have a plan with proper written work procedures and that justifies the need to work that close.
    3. Provide a risk analysis that includes the competency of the workers.
    4. Have steps (2) and (3) approved by authorized management, and documented through the issuance of an Energized Electrical Work Permit.
    5. Use PPE appropriate for working near exposed live parts and rated for the voltage and energy level involved.
- The **Flash Protection Boundary** is the approach limit at a distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur. To cross the Flash Protection Boundary, the qualified person must:
    1. Use PPE appropriate for working near exposed live parts and rated for the voltage and energy level involved.
    2. For systems of 600 volts and less, the flash protection boundary is 4 feet, based on an available bolted fault current of 50kA and a clearing time of 6 cycles for the circuit breaker to act, or any combination of fault currents and clearing times not exceeding 300kA cycles.

3. When working on de-energized parts and inside the flash protection boundary for nearby live exposed parts:
    - If the parts cannot be de-energized, use barriers such as insulated blankets to protect against accidental contact or wear proper PPE.

5.13 – Other Precautions

- Employees shall not reach blindly into areas that might contain exposed live parts.
- Employees shall not enter spaces containing live parts unless illumination is provided that allows the work to be performed safely.
- Conductive articles of jewelry and clothing (including, but not limited to: 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 be handled in such 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, steep tapes, pulling lines, metal scaffold parts, structural members, and chains.
- When an employee works in a confined or enclosed space (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 Confined Space Program).

Re-closing Circuits after a Protective Device Operates

After a circuit is de-energized by a circuit protective devices (e.g. circuit breaker or similar) the circuit may not be manually re-energized until it has been determined that the equipment and circuit can be safely energized. The manual re-closing of circuit breakers or re-energizing circuits by replacing fuses without verifying that the circuit can be safely energized is prohibited. When it can be determined that the over-current device operated because of an overload rather than a fault condition, no examination of the circuit or connected equipment is needed before the circuit is re-energized. Over-current protection of circuits and conductors may not be modified even on a temporary basis.

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5.14 – Energized Electrical Equipment Safety Program

Equipment Labeling

Article 110.16 of the NEC code requires that switchboards, panel boards, industrial control panels, and motor control centers must be to be field marked to warn workers of potential electric arc flash hazards.

- The term Industrial Control Panel covers every enclosure that may contain exposed energized conductors or components.
- Marking (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.
- Markings (labels) shall be located so they are visible to personnel before examination, adjustment, servicing, or maintenance of the equipment.
- Labels shall be either of the 2 examples shown in **Figure 1** and **Figure 2** depending on the available resources of the University.
- The DANGER label (or its equivalent) in **Figure 1**, below, shall be used when information is not presently available. This is the minimum NEC 110.16 requirement.

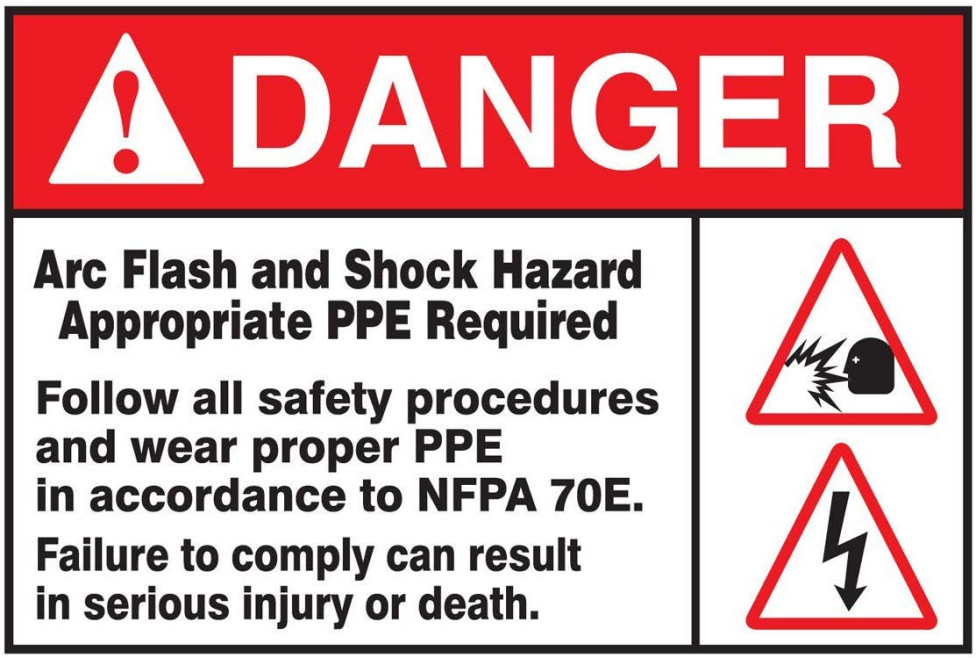

Figure 1 – Minimum Required Equipment Labeling

- The DANGER label (or its equivalent) in **Figure 1**, above, should remind a qualified worker who intends to open the equipment for analysis or work that:
  - Electric arc flash hazard exists.
  - Power shall be turned off before opening.
  - All requirements of NFPA 70E for safe work practices must be followed.
  - Wear appropriate PPE for the specified hazard.
- The second DANGER label (or its equivalent) in **Figure 2**, below, shall be used when a qualified electrical worker or electrical engineer determines the values of the shock and flash protection information.

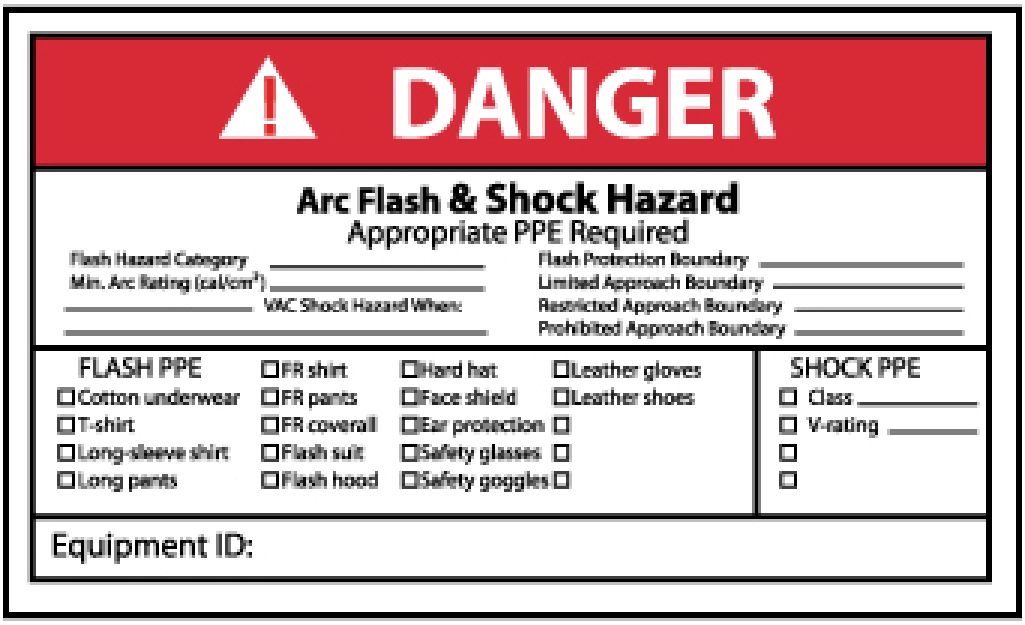

Figure 2 – Detailed Equipment Label (Preferred Label)

- When arc flash and shock data are available for industrial control panels, labels shall include information on flash hazard boundary, the hazard category, required PPE, minimum arc rating, limited approach distances, restricted approach distances, and prohibited approach distances.
- An unqualified person must not be near open or energized equipment.

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5.15 – Arc Flash Hazards

Implementation Procedures

- Immediately place minimum required danger labels on equipment required to be labeled by NEC 110.6 (see Figure 1).
- Until an arc flash risk assessment/hazard analysis is conducted and labels applied, a qualified Electrical Worker using NFPA Table 130.7(C)(9) – *Hazard/Risk Category Classifications and Use of Rubber Insulated Gloves and Insulated and Insulating Hand Tools* – shall for each situation:
    1. Determine the hazard/risk category.
    2. Determine the requirements for the use of V-rated gloves, where V-rated gloves are defined as gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
    3. Determine the requirements for the use of V-rated tools, where V-rated tools are defined as tools rated and tested for the maximum line-to-line voltage upon which the work will be done.

Arc Flash Hazard Analysis

- The University will ensure that a flash hazard analysis/risk assessment is completed as required by NFPA.
    1. The arc flash hazard analysis shall only be completed by a licensed electrical engineer.
    2. The arc flash hazard analysis shall be completed on all major electrical system upgrades or renovations.
    3. The arc flash hazard analysis shall be done for all new electrical system installations.
    4. The University will prioritize arc flash hazard analysis/risk assessment for cases where:
        a) Some equipment may be old, or possibly in poor condition, creating a greater potential for flashover.
        b) Equipment requires greater than average maintenance.
        c) Frequent use of high hazard/risk category personal protective equipment during the conduct of maintenance; qualified electrical workers are frequently wearing high hazard/risk PPE.
- An Arc Flash Hazard analysis/risk assessment will be performed for any equipment where employees might approach an exposed electrical conductor or a circuit part that has not been put in an electrically safe condition.
- An Arc Flash Hazard analysis/risk assessment includes the following actions.

1. Collect data on the facility's power distribution system:
    a) Arrangement of components on a one-line drawing with nameplate specifications of every device.
    b) Lengths and cross-section area of all cables.
2. Contract the electric utility for information including the minimum and maximum fault currents that can be expected at the entrance to the facility.
3. Conduct a short circuit analysis followed by a coordination study.
4. Feed the resultant data into the equations from the latest editions of NFPA 70E or IEEE Standard 1584:
    a) These equations produce the necessary **flash protection boundary distances** and **incident energy** to determine the minimum PPE requirement.
    b) The **flash protection boundary** is the distance at which PPE is needed to prevent incurable burns (2nd degree or worse) if an arc flash occurs. (It is still possible to suffer 1st or 2nd degree burns.)
    c) Install preferred danger label(s) on equipment (see Figure 2).
5. For systems of 600 volts and less, the flash protection boundary is 4 feet, based on an available bolted fault current of 50 kA (kiloamps) and a clearing time of 6 cycles (0.1 seconds) for the circuit breaker to act, or any combination of fault currents and clearing times not exceeding 300 kA cycles (5000 ampere seconds).
6. For other fault currents and clearing times, *see* NFPA 70E.

5.16 – Electrical Repairs or Modifications

Electrical repairs and modifications must be performed by a qualified person. Unauthorized modifications are not permitted.

Building and Laboratory Wiring, Outlet Receptacles, and Breaker Panels

Any modifications to existing electrical service in a laboratory or building needs to be approved and coordinated through the use of the Facilities Service Request (PP25) form. Maintenance or modifications to existing electrical service such as breaker panels, outlet receptacles, wall switches, or wiring must be performed by a qualified Facilities staff member or a licensed electrician. Laboratory personnel may only reset GFCIs. Facilities Maintenance must be contacted to shut off or reset tripped breakers.

Commercial Appliances, Instruments, and Equipment

Maintenance or modifications to commercial appliances, instruments, and equipment should be performed by the manufacturer or an authorized service representative.

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5.17 – Electrical Safety in the Laboratory

The following are requirement specific to electrical safety in the laboratory. This section applies to all staff conducting work in a laboratory at Radford University.

Safe Work Practices

- Keep corrosive chemicals and organic solvents away from electrical cords – these can easily erode the insulation on wires.
- Keep flammable materials away from electrical equipment.
- Extension cords and outlet strips are not permitted in chemical hoods or areas where flammable vapors may be present.
- When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves and shoes with insulated soles.
- Minimize the use of electrical equipment in cold rooms or other areas where condensation is likely. If equipment must be used in such areas, mount the equipment on a wall or vertical panel.
- If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment.

Permanent Electrical Wiring

Permanent electrical outlets must be installed for all stationary electrical equipment (e.g. freezers, refrigerators).

5.18 – Housekeeping

Housekeeping duties may not be performed close to live parts unless adequate safeguards, such as insulating equipment or barriers are provided. Electrically conductive cleaning materials, including steel wool, metalized cloth and silicon carbide, as well as conductive liquid solutions may not be used near energized parts unless procedures are followed which prevent electrical contact typically through de-energization.

5.19 – Contractor Employees

- Contractors are required to comply with applicable Safety and Health regulations such as OSHA, NFPA, and EPA.
- Safety programs used by contractors should meet or exceed all applicable guidelines of this Electrical Safety Program.

- Contractors may be asked to submit copies of their safety program to EHS upon request.

5.20 – Generation, Transmission, and Distribution (High Voltage) Activities Greater Than 600 V

- Reviewed and management approved written procedures for:
  - switching (including notification)
  - testing
  - grounding
  - locking and tagging
- Job briefings during high voltage activities to ensure the safety of personnel
- Established protocol for emergency situations and follow-up
- Availability of appropriate PPE, Tools and Equipment
- Standby persons trained in first aid including cardiopulmonary resuscitation (CPR).
- Systems and equipment designed, installed, and modified in compliance with regulations, standards and industry practices.
- Appropriate controls and work practices for performing high voltage activities, include hazardous locations such as confined spaces, elevations, test areas, etc.
- Legal Requirements: Design, installation, modification, or extension of power distribution systems must be in compliance with applicable regulatory standards or practices.

5.20.1 – Switching Orders (Written Procedures)

- Switching orders are required for all work on all high voltage circuits. A qualified employee (the "originator") writes these orders to assure that all energized circuits entering equipment, or an area in which work is to be done, are opened at a location remote from the work area.
- The switching order shall be written by a qualified person and reviewed by at least one other qualified person. The originator of a switching order must sign it and the individual supervising the work and the high-voltage technician doing the work must review it. Both people shall sign and date the switching order before it may be used. Switching orders must contain, at a minimum:
  - Employment of Lockout/Tagout for each disconnecting device
  - Testing of all exposed terminals, buss ways, and connections with a "glowtector" or "tic-tracer" (or equivalent testing device) after the equipment has been de-energized, and before grounds are applied
  - A list of all tools and PPE required for the job
  - Grounding of all exposed circuits with an approved ground set after the testing device indicates there is no potential present

- Isolation from back feeds from alternate power sources, emergency power supplies, or electronically coupled signals
- Notification of personnel potentially affected by the work (but not involved) prior to power shutdown, and again prior to power restoration
- Compliance with the procedures for control of hazardous energy and electrical safe work practices by any personnel not involved in the initial performance of the switching orders

- Before the start of any switching, a job briefing shall be held by the person in charge of the switching order. All employees that will be involved in the switching shall attend the job briefing. As a minimum the following items shall be reviewed:
  - Reason switching is being performed.
  - Review one line drawing and/or power system status board to assure that all involved understand what will occur.
  - Discuss each step of the switching order.
  - Make job assignments to all involved (who will do what).
  - Discuss safety issues and required PPE.
- Review the following (if required).
  - Electrical clearance requirements and/or Lockout/tagout issues.
  - Location of safety grounds – to be installed or removed and by who.
  - Other issues (such as operational limitations).
- Switching orders list sequentially each step that is required to take high-voltage out of service. Each switching step shall be checked off when completed. It is recommended that the time the switching step is completed be recorded. The following switching procedures and information items are recommended:
  - The person receiving a switching command should repeat the switching command and have it confirmed by the person issuing the order before executing the command.
  - If switching commands are given by radio, a unique switching channel should be used. Cross talk on the radio during switching could cause a switching error.
  - When the switching is complete the status of the power system should be documented. Use of a status board or pin board is one method of accomplishing this issue.
  - Information on abnormalities of the power system should be documented in order to inform off shift personnel who may be involved in responding to power system problems. It is recommended that this information be posted near a power system status board or pin board.
  - It is recommended that open electrical clearances (or parts of the power system under lockout/tagout), the location of any safety grounds, and other

power system safety issues be posted near the power system status board or pin board.
    - A second person should stand clear and be a safety observer for the person doing the switching. The safety observer should ensure that each step the switch operator is about to perform is correct.
- All non-emergency work on high-voltage equipment must be planned in advance.

5.20.2 Periodic Inspection of High-Voltage Work

Periodic inspection of high-voltage work must be conducted by someone other than those engaged in the work to ensure that safe work procedures, practices, and use of personal protective equipment are being implemented. Documentation of the inspection must be noted on the switching orders.

5.20.3 Restoration of Power

- Restoration of power may be treated as a continuation of the original switching order, or as a separate order. The restoration order lists the step-by-step procedure to:
    - Verify that all personnel involved have completed their work and have returned to a safe area
    - Check for removal of all tools, tags, locks, grounds
    - Perform "high-pot" or phasing tests, where applicable
    - Secure panels and covers
    - Implement switching operations

5.20.4 Emergencies

- Formal switching orders may not be available in emergency situations. Switching and repairs must be limited to the minimum necessary to eliminate any exposure to personnel or property. The high-voltage technician and the supervising individual must agree on the appropriate actions before each step is taken. The manager has the authority to make necessary emergency decisions. Written procedures are required to complete work beyond the initial response to an emergency.

5.20.5 Grounding Procedures

- The high-voltage technician must follow these steps during a grounding procedure:
    - Determine that equipment is de-energized before grounds are applied

- Use test equipment, approved for high voltage use, only on an area that has been isolated by opening breakers or disconnects between the equipment and all sources of power
- Apply this test equipment to all exposed terminals and conductors in the equipment to verify de-energization (3 point test of meter required)
- Touch, using a "hot stick," the grounded end of the grounding set to all exposed terminals and conductors; after which, firmly attach the ground clamps to all phase terminals or conductors
- Use protective grounding equipment capable of conducting the maximum fault current available at the point of the system being grounded for the time necessary to clear the fault:
- Determination of the required ground conductor size must be made by the location's facilities engineering.
- In no case is the protective grounding equipment to have an amperage capacity less than that provided by a No.2 American Wire Gauge (AWG) copper conductor, or non-U.S. equivalent.

5.20.6 High-Voltage Testing

- High-voltage testing includes, at a minimum, the following work practices:
  - Guarding of permanent test areas with walls, fences, or barriers
  - Control of access to field test areas through the use of signs, physical barriers or barricades, or by assigning an observer to monitor the area
  - Routine safety checks of the test area by the test operator in charge
  - Grounding practices in compliance with the National Electrical Safety Code.

5.20.6 Confined Spaces

- Individuals entering confined electrical spaces such as high-voltage manholes and vaults must be in compliance with the requirements of the Entry Procedures for Confined Spaces as identified in Confined Spaces Safety Program.

6.0 Working Space About Electric Equipment

6.1 – Spaces About Electric Equipment

- **Access.** 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.** Working space for equipment operating at 600 volts, nominal, or less to ground and likely to require examination, adjustment, service, or maintenance while energized shall comply with the dimensions of 70E 400.15(A)(1), 400.14(A)(2), and 400.15(A)(3) or as required or permitted elsewhere in the 70E Standard.
- **Depth of Working Space.** The depth of the working space in the direction of live parts shall be not less than that indicated in Table 400.15(A)(1) unless the requirements of 400.15(A)(1)(a), 400.15(A)(1)(b), or 400.15(A)(1)(c) are met. Distances shall be measured from exposed live parts if such are exposed or from the enclosure or opening if the live parts are enclosed.

Table 400.15(A)(1) Working Spaces

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
0-150	900mm(3 ft)	900 mm(3 ft)	900mm(3 ft)
151-600	900mm(3 ft)	1m(3-1/2 ft)	1.2 m (4 ft)

- **Condition 1:** Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulate wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.
- **Condition 2:** Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls shall be considered as grounded surfaces.
- **Condition 3:** Exposed live parts on both sides of the work space (not guarded as provided in condition 1) with the operator between.

- **Dead-front Assemblies.** Working space shall not be required in the back or sides of assemblies, such as dead-front switchboards or motor control centers, where all connections and all renewable or adjustable parts, such as fuses or switches, are accessible from all locations other than the back or sides. Where rear access is required to work on non-electrical parts on the back of enclosed equipment, a minimum horizontal working space of 762 mm (30 in) 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 where electric equipment is being replaced, Condition 2 working clearance shall be permitted between dead- front switch boards, panel boards, or motor control centers located across the aisle from each other where conditions of maintenance 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. Qualified electrical workers who are authorized will service the installation.

- **Width of Working Space**. The width of the working space in front of the electrical equipment shall be the width of the equipment or 750 mm (30 in), whichever is greater. In all cases, the work space shall permit at least a 90 degree opening of equipment doors or hinged panels.
- **Height of Working Space**. The workspace shall be clear and extend from the grade, floor, or platform to the height required by 70E 400.15(E). Within the height requirements of this section, other equipment that is associated with the electrical installation and is located above or below the electrical equipment shall be permitted to extend not more than 150 mm (6 in) beyond the front of the electrical equipment.
- **Clear Spaces**. Working space required by the 70E standard shall not be used for storage. When normally enclosed live parts operating at 50 volts or more are exposed for inspection or service, the working space, if in a passageway or general open spaced shall be suitably guarded.

6.2 – Access and Entrance to Working Space

- **Minimum Required**. At least one entrance of sufficient area shall be provided to give access to the working space about electric equipment.
- **Large Equipment**. For equipment rated 1200 amperes or more and over 1.8 m (6ft) wide that contains overcurrent devices, switching devices, or control devices, there shall be one entrance to the required working space not less than 610 mm (24in) wide and 2.0 m (6-1/2 ft) high at each end of the working space. Where the entrance has a personnel door(s), the door(s) shall open in the direction of egress and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressures. A single entrance to the required working space shall be permitted where either of the conditions in 400.14(c)(2)(a) or 400.14(c)(2)(b) is met.
- **Unobstructed Exit**. Where the location permits a continuous and unobstructed way of exit travel, a single entrance to the working space shall be permitted.
- **Extra Working Space**. Where the depth of the working space is twice that required by 400.15(A)(1), a singled entrance shall be permitted. It shall be located so that the distance from the equipment to the nearest edge of the entrance is not less than the minimum clear distance specified in Table 400.15(A)(1) for equipment operating at that voltage and in that condition.

6.3 – Illumination

Illumination shall be provided for all working spaces about service equipment, switchboards, panel boards, or motor control centers installed indoors. Employees shall not enter spaces containing electrical hazards unless illumination is provided that enables the employees to perform the work safely. Additional lighting outlets shall not be required where the work space is illuminated by an adjacent light source. In electrical equipment rooms, the illumination shall not be controlled by automatic means only.

Where lack of illumination or an obstruction precludes the observation of the work to be performed, 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.

6.4 – Headroom

The minimum headroom of working spaces about service equipment, switchboards, panel boards, or motor control centers shall be 2.0 m (6 ½ ft). Where the electrical equipment exceeds 2.0 m (6 ½ ft) in height, the minimum headroom shall not be less than the height of the equipment.

6.5 – 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.*

7.0 Personal Protective Equipment (PPE)

7.1 – General Requirements

- Employees working in areas where there are potential electrical hazards must use PPE that is appropriate for the specific work to be performed. The electrical tools and protective equipment must be specifically approved, rated, and tested for the levels of voltage to which an employee may be exposed.
- The University shall provide, as needed, electrical protective equipment (e.g. Arc Flash Gear) required by this program. Such equipment may include 11 calorie, and 40 calorie

rated Arc Flash apparel (until a full arch flash hazard analysis is completed), eye protection, head protection, hand protection, insulated footwear, and face shields where necessary.

- Employees shall wear 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.
- Employees shall wear protective equipment for the eyes whenever there is a danger of injury from electric arcs, flashes, or from flying objects resulting from an electrical explosion.
- Employees shall wear rubber insulating gloves where there is a danger of hand or arm contact with live parts or possible exposure to arc flash burn.
- Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required. Insulated soles shall not be used as primary electrical protection.
- Face shields must have arc rating 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.
- Electrical Protective Equipment must be selected to meet the criteria established by the American Society of Testing and Materials (ASTM) and by the American National Standards Institute (ANSI).
- Insulating equipment made of materials other than rubber shall provide electrical and mechanical protection at least equal to that of rubber equipment.
- PPE must be maintained in a safe, reliable condition and be inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of having caused damage.
- Employees must use insulated tools and handling equipment that are rated for the voltages to be encountered when working near exposed energized conductors or circuits. Tools and handling equipment should be replaced if the insulating capacity is decreased due to damage.
- Fuse handling equipment (insulated for circuit voltage) must be used to remove or install fuses.
- Ropes and hand lines used near exposed energized parts must be non-conductive.
- Protective shields, barriers, or insulating materials must be used to protect each employee form shock, burns, or other electrical injuries that might result from that person's accidentally contacting energized equipment, or where dangerous electric heating or arcing might occur.

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7.2 – Protective Clothing

Protective Clothing Characteristics

Category	Cal/cm^2	Clothing
0	1.2	Untreated Cotton
1	5	Flame retardant (FR) shirt and FR pants
2	8	Cotton underwear, FR shirt and FR pants
3	25	Cotton underwear, FR shirt, FR pants and FR coveralls
4	40	Cotton underwear, FR shirt, FR pants and double layer switching coat and pants

Flame Resistant (FR) Apparel

- FR apparel shall be visually inspected before each use. FR apparel that is contaminated or damaged shall not be used. Protective items that become contaminated with grease oil flammable liquids, or combustible liquids shall not be used.
- The garment manufacturer's instructions for care and maintenance of FR apparel shall be followed.
- When the apparel is worn to protect an employee, it shall cover all ignitable clothing and allow for movement and visibility.
- FR apparel must cover potentially exposed areas as completely as possible. FR shirt sleeves must be fastened and FR shirts/jackets must be closed at the neck.
- Non-melting, flammable garments (i.e. cotton, wool, rayon, silk, or blends of these materials) may be used as underlayers beneath FR apparel.
- Fibers that can melt, such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers next to skin. (An incidental amount of elastic used on non-melting fabric underwear or socks shall be permitted).
- Garments worn as outer layers over FR apparel (i.e. jackets or rainwear) must also be made from FR material.
- Flash suits must permit easy and rapid removal by the user.

7.3 – Rubber Insulating Equipment

- Rubber insulating equipment includes protective devices such as gloves, sleeves, blankets, and matting.
- Insulating equipment must be inspected for damage before each day's use and immediately following any incident that could have caused damage.
- An air test must be performed on rubber insulating gloves before each use.
- Insulating 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. This testing must be performed by at least two qualified workers.
- Where the insulating capability of protective equipment is subject to damage during use, the insulating material shall be protected by an outer covering of leather or other appropriate materials.
- Rubber insulating equipment must be tested according to the schedule supplied by the manufacturer.
- Rubber insulating equipment must be stored in an area protected from light, temperature extremes, excessive humidity, ozone, and other substances and conditions that may cause damage.
- Repairs to rubber insulating equipment are not allowed; damaged equipment shall be disposed of, and new equipment acquired.

7.4 – Insulated Tools and Materials

- Only insulated tools and equipment shall be used within the Limited Approach Boundary of exposed energized parts.
- Insulated tools shall be rated for the voltages on which they are used.
- Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
- Fuse or fuse holder handling equipment, insulated or the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.
- Ropes and hand-lines used near exposed energized parts shall be nonconductive.
- Portable ladders used for electrical work shall have nonconductive side rails.

7.5 – Entry Restrictions

- Barricades shall be used in conjunction with safety signs to prevent or limit access to work areas containing live parts. 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.

8.0 – Emergency Response

8.1 – Electrical Injuries

If someone has received an electrical shock, **do not** touch the person, equipment, or cord. Call RUPD immediately (540-831-5500) or dial 911. If it is safe to do so, shut down the power source immediately.

8.2 – Fire Extinguishers for Electrical Fires

If an electrical fire occurs, leave the area immediately and follow the building Emergency Action Plan (EAP). If it is safe to do so, shut down the power source while exiting the area. Only employees trained in the use of a fire extinguisher may use one to extinguish an electrical fire. A type C fire extinguisher is to be used on electrical fires. The ABC fire extinguishers installed in many locations on campus are also suitable for electrical fires.

9.0 Training Requirements

Employees working on or near energized or potentially energized electrical circuitry of fifty (50) volts to ground or greater shall be designated as a qualified electrical worker and trained in energized electrical safe work practices and procedures, and retrained as necessary.

9.1 – Qualified Person / Qualified Electrical Worker (QEW)

Qualified persons must receive training in avoiding the electrical hazards associated with working on nor near exposed energized parts prior to performing energized electrical work. Such training will be provided when the employee is initially assigned to the job. This training will be either provided or coordinated by EHS. Refresher training will be provided every year, when hazards change, or when new technologies or new types of equipment are introduced to the worker.

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The following requirements are to be included in the training of Qualified Electrical Workers (QEW) or Qualified Persons (i.e. individuals who have skills and knowledge related to the construction and operation of electrical equipment and installations):

- The Hazardous Energies Control and Lockout/Tagout Program (OCS-201), including safe work practices required to safely de-energize electrical equipment.
- Universal electrical safety procedures.
- Skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment.
- On-the-job training with a qualified electrical worker.
- Skills and techniques necessary to determine the nominal voltage of exposed live parts.
- The approach distances specified in Table 130.4 (D)(a) and 130.4(D)(b) and the corresponding voltages to which the QEW will be exposed.
- Selection and use of proper work practices, PPE, tools, insulating and shielding materials, and equipment for working on or near energized parts.
- Familiarity with updates of NFPA 70E.

QEWs should also be trained in recognizing signs and symptoms of electrical shock, heart fibrillation, electric burns, and proper first aid protocols for these conditions. Therefore, it is recommended that they have the following additional training:

- Basic Cardio Pulmonary Resuscitation (CPR)
- Automated External Defibrillator (AED)
- Contacting emergency personnel and basic first aid
- Methods of releasing victims in contact with energized electrical conductors or circuit parts.

The designation of QEW shall be determined by the immediate supervisor upon the employee's successful completion of the training requirements outlined in this section and the Qualified Electrician Checklist (Appendix F).

General Guidelines for "Qualifying" Personnel

Qualification for electrical or electronics work is determined by the employee's Supervisor or the Manager of Electrical Services. It should be based upon a risk review of known electrical hazards in the work place versus the known technical knowledge and safe-work expertise of the "qualified" worker.

A worker is determined "qualified" by their Supervisor or the Manager of Electrical Services, when they can demonstrate adequate knowledge to work safely with electricity through a combination of classroom training (including required periodic retraining), formal electrical trade recognition, military, college or other training, work experience, and on-the-job training. Formal training can be the completion of apprenticeship, journeyman or comparable training. Experience may include formal technical related education courses and hands-on field or classroom lab work that may or may not result in licenses or certifications.

Specific "Qualifying Criteria"

Supervisors should use the Qualified Electrician Checklist (Appendix F) to help determine whether an individual is "qualified" to perform specific electrical work. If the supervisor cannot verify a person's qualifications, assistance from the Manager of Electrical Services and/or EHS should be obtained.

9.2 – Documentation of Training and Experience

Documentation of training and experience shall be kept by each department and additionally should be included in the EHS training database. Experience received by Qualified Persons must be maintained for all personnel covered by this program. Documentation is necessary to demonstrate that individuals have met the training and experience requirements for the types of work being performed.

10.0 - References

- NFPA 70E – "Standards for Electrical Safety in the Workplace", 2015 edition.
- NFPA 70 – National Electric Code (NEC)
- IEEE Standard 1584-2002, "Guide for Performing Arc Flash Hazard Calculations".
- OSHA 29 CFR 1910.331 through 1910.335, "Electrical Safety-Related Work Practices".
- OSHA 29 CFR 1926.404(b)(1)(ii).
- EHS Document OCS-201 – "Hazardous Energy Control and Lockout/Tagout Program".

11.0 Appendices

- **A – Energized Electrical Work Flow Chart**
- **B – Energized Electrical Work Permit**
- **C – PPE by Hazard Category**
- **D – PPE for Common Electrical Work Tasks [130.7(C)(10); 130.7(C)(15)(a)]**
- **E – Approach Boundaries to Live Parts for Shock Protection**

- **F – Qualified Electrician Checklist**

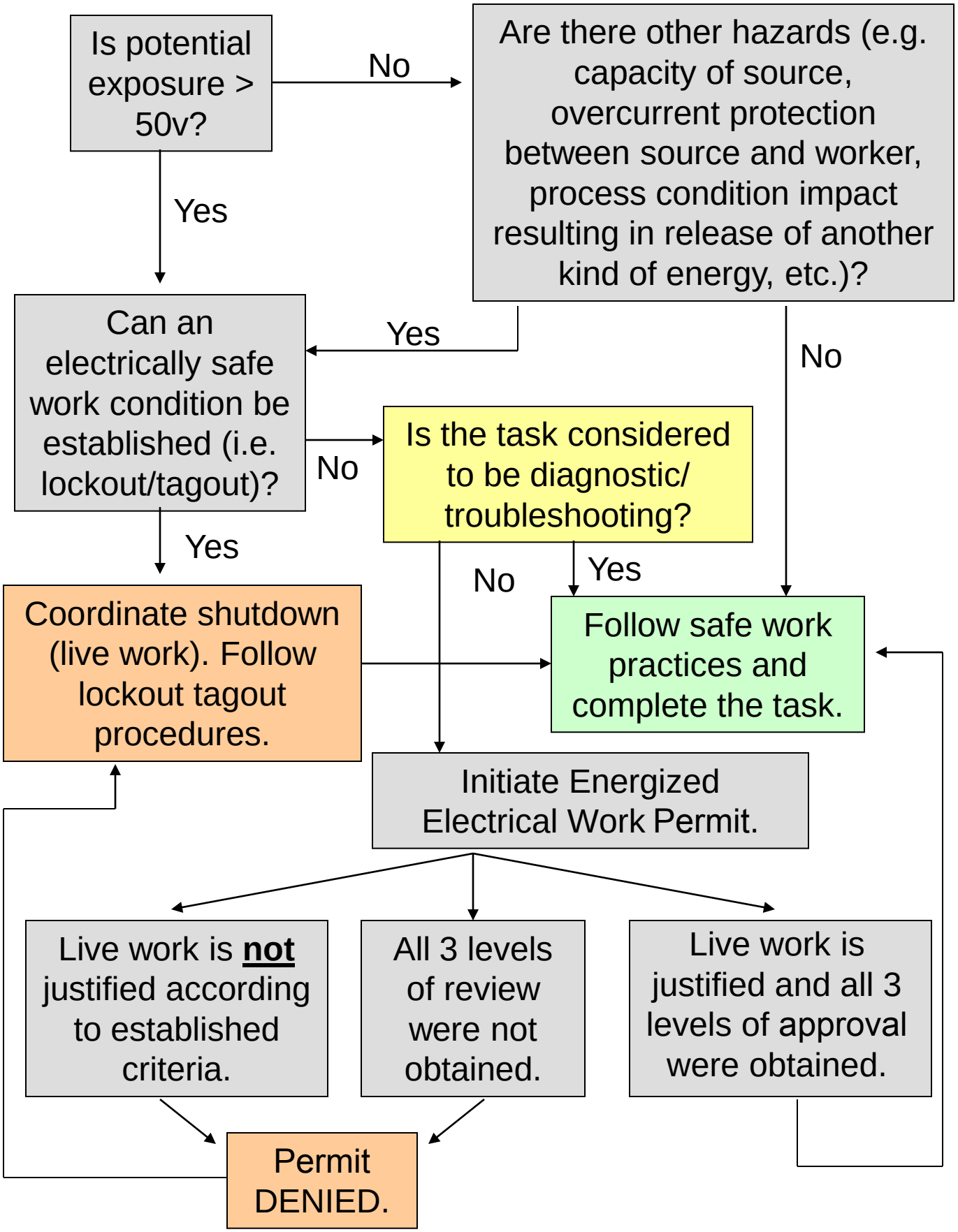
12.0 Document Revision History

Revision	Section(s) Changed	Change(s) Made:	Date
00	All	Initial Draft	Unknown
01	All	Program Overhaul, new draft version	07/21/17

13.0 **Document Author(s):** Avraham Boruchowitz, CSP, CHMM

Radford University Electrical Safety Program - Appendix A

Energized Electrical Work Flow Chart



Radford University Electrical Safety Program – Appendix B

ENERGIZED ELECTRICAL WORK PERMIT

SECTION 1. (To be completed by the qualifed person requesting the permit.)
DESCRIPTION OF WORK AND JUSTIFICATION FOR PERFORMING THAT WORK ENERGIZED.

Description of work: _____

_____

Justification: (Check all that apply)

De-energization introduces additional or increased hazards:

_____ Violation of an Environmental Permit
_____ Deactivation of emergency alarm systems
_____ Shutdown of hazardous ventilation equipment
_____ Other - Describe _____

Proposed written procedure for the work to be performed must be attached for review.

De-energization is not feasible due to equipment design or operational limitations:

_____ Tasks that can only be performed with circuit energized
_____ Would require continuous operating process to be shutdown
_____ Other - Describe _____

Requested by: _____ **Signature:** _____

Title: _____ **Date:** _____

SECTION 2. Hazard Analysis
(To be completed by Requester's Supervisor)
Hazard Risk Category _____ **(See Table 130.7(C)9(a) in Appendix C)**

Minimum approach safe distance _____
Less than 600 V -- 4 feet

TECHNICAL REQUIREMENTS	Yes	Done		Yes	Done
Written Procedure			Approved Insulated Hand Tools		
Review Electrical Live Work			Live-line Tools (e.g., hot sticks)		
Job Briefing Discussion			CAT III or IV rated Voltmeter		
Barricades			Approved Phasing Tester		
Personal Protective Equipment			Illumination		
Class E Hard hat			Limited work space considerations[1]		
Safety glasses			Conductive material considerations[1]		
Polycarbonate tinted face shield			Portable ladders		
Fire Resistant Clothing level ____			Conductive work apparel[1]		
Flash suit Level _____			Interlock considerations[1]		
Voltage rated insulated gloves			Housekeeping requirements[1]		
Voltage rated insulated blankets			2 Qualified-person teams		
Voltage rated insulated matting			Other:		
Voltage rated insulated shielding			Other:		
Grounding cables			Other:		
Bonding cables			(1 *List in a written procedure*)		

SECTION 3. Reviews

Reviewed By: _____ **Date**
Requester's Supervisor

Reviewed By: _____ **Date**
Qualified Person (other than the Requester)

SECTION 4. Approvals

_____ **Date**
Manager Electrical Services
I have reviewed the permit and approve the proposed energized electrical work.

_____ **Date**
Director, Environmental Health and Safety
I have reviewed the permit and approve the proposed energized electrical work.

_____ **Date**
Director, Facilities Management
I have reviewed the permit and approve the proposed energized electrical work.

Qualified Worker **Date** **Qualified Worker** **Date** **Qualified Worker** **Date**

Appendix B (cont'd)

Energized Electrical Work Permit Instructions

SECTION 1:

- The requester shall describe what work they believe needs to be performed energized.
- The requester shall justify, by checking all reasons that apply, why the electrical work needs to be performed in an energized state.
- The requester shall sign, print his/her title and date the request.

SECTION 2:

- The requester's Supervisor, (or qualified designee), shall review the request and evaluate if it is necessary to work energized.
- If the supervisor (or qualified designee), concurs that it is necessary to work energized, he/she will then establish the Hazard Risk Category (0, 1, 2, 3, 4), the Minimum Approach Safe Distance and establish the technical requirements in Section 2 to perform the work with proper precautions.
- Unless a written procedure is not needed for the operation, the supervisor (or qualified designee), will write the procedure (in consultation with appropriate Electrical Engineers, if necessary),.

- Written procedures shall include descriptions or detailed list of the technical requirements noted on the permit (e.g., housekeeping requirements, limited work space, conductive material, conductive work apparel, or interlock considerations). Procedures will outline the steps necessary to complete the work safety along with any special precautionary "NOTES" or "WARNINGS". The written procedures shall be reviewed in a job briefing and attached to the permit.

SECTION 3: The permit is reviewed by a the requester's Supervisor (or qualified designee), and by an additional qualified person/employee before submitted for approval.

SECTION 4: The permit is reviewed by the Manager Electrical Services, EHS Director, and Facilities Management Director. All approvals are required before work may begin.

Prior to the start of the work: Qualified Workers assigned to the energized work shall sign and date the permit to indicate that they have read and understand the work precautions and any associated procedures.

The permit must be posted by the work area until the work operations covered by the permit have been completed.

PERMIT EXPIRATION: The permit will expire when:

1- work operations covered by this permit have been completed; or

2- the technical requirements listed on the permit are no longer suitable for the hazards present; or

3- if the hazard category changes.

Radford University Electrical Safety Program

Appendix C – PPE by Hazard Category

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Appendix D – PPE for Common Electrical Work Tasks

[130.7(C)(10); 130.7(C)(15)(a)]

Panelboards or other equipment rated 240V and below	
Job tasks performed on energized equipment	**Protective Requirements**
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary. (hazard/risk category 0)	**Non-melting or untreated natural fiber:** • Long sleeve shirt • Long pants **PPE:** • Safety glasses or goggles • Leather gloves (as needed)
Circuit breaker or fused switch operation with covers on. (hazard/risk category 0)	**Non-melting or untreated natural fiber:** • Long sleeve shirt • Long pants **PPE:** • Safety glasses or goggles • Leather gloves (as needed)
Circuit breaker or fused switch operation with covers off. (hazard/risk category 0)	**Non-melting or untreated natural fiber:** • Long sleeve shirt • Long pants **PPE:** • Safety glasses or goggles • Leather gloves (as needed)
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). (hazard/risk category 0)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Hardhat • Safety glasses or goggles • Leather gloves

Panelboards or other equipment rated 240V and below	
Job tasks performed on energized equipment	**Protective Requirements**
Work on energized electrical conductors and circuit parts, including voltage testing and troubleshooting. (hazard/risk category 1)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves
Remove or install circuit breakers or fused switches. (hazard/risk category 1)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts). (hazard/risk category 1)	**Non-melting or untreated natural fiber:** • Shirt (long sleeve) • Pants (long) **PPE:** • Safety glasses or goggles • Leather gloves (as needed)
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by branch circuit of the panelboard. (hazard/risk category 1)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves

Panelboards or Switchboards Rated greater than 240 V and up to 600 V (with molded case or insulated case circuit breakers)	
Job tasks performed on energized equipment	**Protective Requirements**
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary. (hazard/risk category 1)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves (as needed)
Circuit or fused switch operation with covers on. (hazard/risk category 0)	**Non-melting or untreated natural fiber:** • Shirt (long sleeve) • Pants (long) **PPE:** • Safety glasses or goggles • Leather gloves (as needed)
Circuit breaker or fused switch operation with covers off. (hazard/risk category 1)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves • Leather work shoes (as needed)

Panelboards or Switchboards Rated greater than 240 V and up to 600 V (with molded case or insulated case circuit breakers)	
Job tasks performed on energized equipment	**Protective Requirements**
Work on energized electrical conductors and circuit parts, including voltage testing and troubleshooting. (hazard/risk category 2*)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 8) • OR Coveralls (Cal rating of 8) • OR Face-shield (Cal rating of 8) and Balaclava (Cal rating of 8) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves • Leather work shoes
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switch. (hazard/risk category 2*)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 8) • OR Coveralls (Cal rating of 8) • OR Face-shield (Cal rating of 8) and Balaclava (Cal rating of 8) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves • Leather work shoes

Other 600 V Class (277 V through 600 V, nominal) Equipment Lighting or small power transformers (600 V, maximum)	
Job tasks performed on energized equipment	**Protective Requirements**
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts) (hazard/risk category 2*)	**FR Clothing, minimum arc rating of 8:** • Long sleeve shirt and long pants (Cal rating of 8) • OR Coveralls (Cal rating of 8) • OR Face-shield (Cal rating of 8) and Balaclava (Cal rating of 8) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Leather gloves • Leather work shoes
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts) (hazard/risk category 1)	**FR Clothing, minimum arc rating of 4:** • Long sleeve shirt and long pants (Cal rating of 4) • OR Coveralls (Cal rating of 4) • Face-shield or flash suit hood (Cal rating of 4) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Leather gloves • Leather work shoes (as needed)

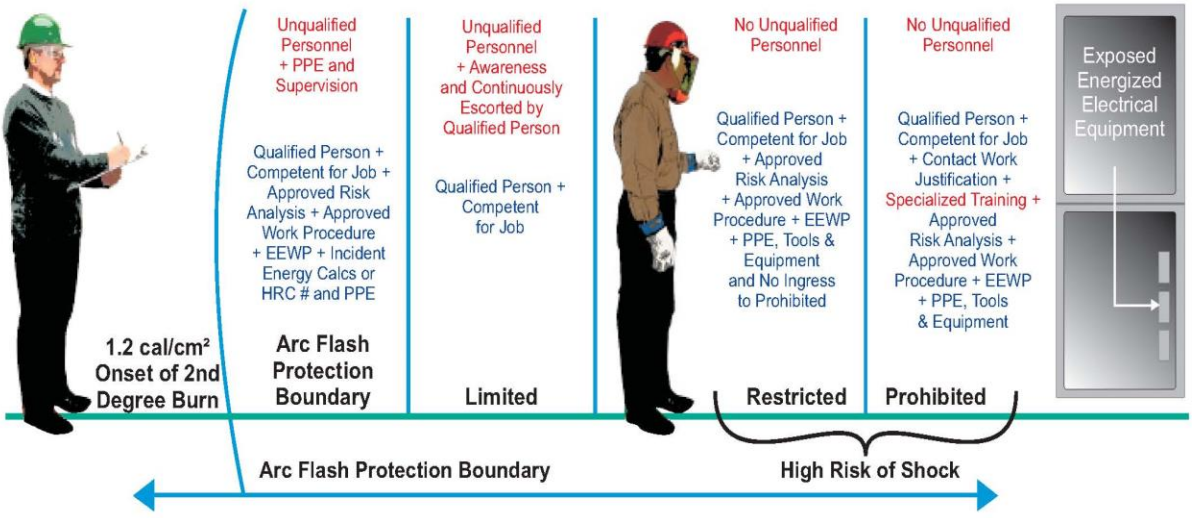
Other 600 V Class (277 V through 600 V, nominal) Equipment	
Job tasks performed on energized equipment	**Protective Requirements**
Work on energized electrical conductors and circuit parts, including voltage testing. (hazard/risk category 2*)	**FR Clothing, minimum arc rating of 8:** • Long sleeve shirt and long pants (Cal rating of 8) • OR Coveralls (Cal rating of 8) • OR Face-shield (Cal rating of 8) and Balaclava (Cal rating of 8) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves • Leather work shoes
Application of safety grounds, after voltage testing (hazard/risk category 2*)	**FR Clothing, minimum arc rating of 8:** • Long sleeve shirt and long pants (Cal rating of 8) • OR Coveralls (Cal rating of 8) • OR Face-shield (Cal rating of 8) and Balaclava (Cal rating of 8) • Jacket, parka, or rainwear (as needed based on conditions) **PPE:** • Safety glasses or goggles • Rubber insulating gloves • Leather gloves Leather work shoes

Radford University Electrical Safety Plan

Appendix E – Approach Boundaries to Live Parts for Shock Protection

All dimensions are distance from live part to employee.

Boundaries for Arc Flash Protection and Shock - Approach Limits



Note:
Arc Flash + Shock PPE for 600 V Energized Work Task as example

ESPS electrical safety™ PROGRAM SOLUTIONS inc.

Example of Detailed Arc Flash and Shock Warning Label

WARNING

Arc Flash and Shock Hazard
Appropriate PPE Required

ARC FLASH PROTECTION		SHOCK PROTECTION	
Working Distance:	18 inches	Shock Hazard when cover is removed	600 VAC
Incident Energy:	6.0 cal/cm²	Limited Approach	42 inch
Arc Flash Protection Boundary	48 inch	Restricted Approach	12 inch
		Prohibited Approach	1 inch
		Glove Class:	0

Refer to CSA Z462 and company's Electrical Safety Program for PPE requirements.

Equipment Name: MCC#3 **Nov. 19, 2009** Std: IEEE 1584
Arc Flash Analysis By: XYZ Consulting File: "ABC PLANT REV X. xyz"

CSA Z462 Table 1 / NFPA 70E Table 130.2 (C)
Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection

	Limited	Restricted	Prohibited
480V	3 ft. 6 in. 1.07 m	1 ft. 0 in. 305 mm	0 ft. 1 in. 25 mm
600V	3 ft. 6 in. 1.07 m	1 ft. 0 in. 305 mm	0 ft. 1 in. 25 mm
4160V	5 ft. 0 in. 1.52 m	2 ft. 2 in. 660 mm	0 ft. 7 in. 187 mm
13800V	5 ft. 0 in. 1.52 m	2 ft. 2 in. 660 mm	0 ft. 7 in. 187 mm

Appendix F

RADFORD UNIVERSITY QUALIFIED ELECTRICIAN CHECKLIST

ELECTRICIAN PRINTED NAME: _____

SUPERVISOR PRINTED NAME: _____

DATE: _____

QUALIFICATION	YES
SAFETY TRAINING - ASBESTOS AWARENESS	
SAFETY TRAINING - LOCKOUT/TAGOUT (LOTO)	
SAFETY TRAINING - ELECTRICAL HAZARD AWARENESS	
SAFETY TRAINING - ARC FLASH	
GENERAL AWARENESS TRAINING PROVIDED FOR 4160 MEDIUM VOLTAGE LOOP	
PROVIDED UNIVERSITY FIRE RATED CLOTHING GUIDELINES - PPE REQUIREMENTS	
PROVIDED UNIVERSITY ELECTRICAL SAFETY PROGRAM	
SHADOW EXISTING QUALIFIED ELECTRICIAN FOR A PERIOD OF 1 MONTH (4 WORK WEEKS)	
SHOWN BY SUPERVISION WHERE RESOURCES SUCH AS NFPA, OSHA, AND BUILDING CODE BOOKS ARE LOCATED	
SHOWN BY SUPERVISION HOW TO LOCATE DRAWINGS AND DOCUMENTS PERTAINING TO EXISTING ELECTRICAL SYSTEMS	
SHOWN BY SUPERVISION ELECTRICAL VAULT AND MAIN SWITCHGEAR LOCATIONS ON CAMPUS	
SHOWN EXAMPLES OF SPECIFIC EQUIPMENT INCLUDING: MOTOR CONTROL CENTERS, GENERATORS, CHILLERS, ELEVATORS, FIRE ALARM SYSTEMS, RUPD FIRE ALARM HEADEND	
REVIEWED PROCEDURES FOR HOT ELECTRICAL WORK PERMIT	
DPOR ELECTRICAL JOURNEYMAN'S LICENSE	
PROVIDED APPROPRIATE KEYS TO EXECUTE DAILY WORK ASSIGNMENTS	

SIGNATURES:

EMPLOYEE: _____

SUPERVISOR: _____