Electrical Safety Manual

UNIVERSITY OF ALABAMA

OFFICE OF ENVIRONMENTAL HEALTH & SAFETY

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1. Introduction

This program establishes minimum standards to prevent hazardous electrical exposures to personnel and ensure compliance with regulatory requirements applicable to electrical systems. Working on equipment in a de-energized state is **required** unless de-energizing introduces an increased hazard or is infeasible. This program is designed to help ensure that energized electrical work at The University of Alabama is performed safely by qualified electrical workers, who are trained and provided with the appropriate safe work procedures, protective equipment and other controls. The program is intended to protect employees against electrical shock, burns and other potential electrical safety hazards as well as comply with regulatory requirements.

a) Purpose

This program has been established in order to:

- Ensure the safety of employees who may work on or near electrical equipment.
- Ensure that employees understand and comply with safety standards related to electrical work.
- Ensure that personnel follow consistent practices during the progress of electrical work.
- Comply with recognized safety practices according to the following six points:
  1) Provide and demonstrate a safety program with defined responsibilities.
  2) Determine the degree of arc flash hazard by qualified personnel.
  3) Affix warning labels on equipment.
  4) Provide personal protective equipment (PPE) for workers.
  5) Provide documented training
  6) Provide appropriate tools for safe work.

b) Scope

This program applies to all work performed by UA personnel regardless of job site location.

c) References Utilized

NFPA 70-E, "Standard for Electrical Safety in the Workplace"
IEEE Standard, "Guide for Performing Arc Flash Hazard Calculations"
OSHA 29 CFR 1910.331 through 1910.335, "Electrical Safety-Related Work Practices"
OSHA 29 CFR 1910.147, "The Control of Hazardous Energy (Lockout/Tagout)"

2. Definitions

Definitions are provided to clarify terms and provide additional resource information.

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

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 (or Isolating) switch - A device designed to close and/or open an electric circuit.
Energized electrical work - Repair, maintenance, troubleshooting, or testing on electrical circuits, components, or systems while energized (i.e., live). Only Qualified Electrical Workers are permitted to work on energized circuitry of 50 volts/25 amps to ground or greater.

Energy source - Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.

Exposed electrical parts - Energized parts that can be inadvertently touched or approached nearer than a safe distance by a person. Parts not suitably guarded, isolated, or insulated. Examples include terminal contacts or lugs, and bare wiring.

Flash Protection 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.

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 that is less than that required to operate the over-current protective device of the supply circuit.

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.

Hazardous Location - An area in which an airborne flammable dust, vapor or gas may be present and would represent a hazard if a source of ignition were present (see National Fire Protection Association (NFPA).

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

Isolating 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 – An approach limit is a distance from an exposed live part within which a shock hazard exists.

Lockout - The placement of a lock on an energy-isolating device according to procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

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

NEC – National Electrical Code which is also referenced as NFPA 70.
Prohibited Approach Boundary – An approach limit distance from an exposed live part within which work is considered the same as making contact with the live part.

Qualified Electrical Worker – 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 electrical workers 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.

An employee who has completed all applicable coursework training and is undergoing on-the-job training is a "Qualified Electrical Worker in Training". A Qualified Electrical Worker in Training who 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 a "Qualified Electrical Worker".

Only a Qualified Electrical Worker is allowed to work within the limited approach boundary of exposed energized electrical conductors and circuit parts operating at 50 volts or more.

Qualified electrical workers 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 to life or property.

Whether a person is considered to be a "qualified" person will depend upon various circumstances in the workplace. It is possible and, in fact, likely for an individual to be considered "qualified" with regard to certain equipment in the workplace, but "unqualified" as to other equipment. Tasks that are performed less often than once per year shall require retraining before the performance of the work practices involved.

Retraining must be provided for all Qualified Electrical Workers and additional training shall be provided anytime an employee is not complying with the safety-related work practices. Additionally training must be provided anytime new technology, new

equipment or changes in procedures necessitate any changes in the normal work practices.

Restricted Approach Boundary – 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.

Remote-control Circuit - Any electric circuit that controls any other circuit through a relay or an equivalent device.
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.

Setting Up - Any work performed to prepare a machine or equipment to perform its normal production operation.

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.

Tagout - The placement of a tagout device on an energy-isolating device according to procedure to indicate that the equipment may not be operated until the tagout device is removed.

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

Voltage, high - Circuits with a nominal voltage more than 50 volts.

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.

Wet location - Installations subject to saturation with water or other liquids.

3. Responsibilities

a) The University of Alabama Administration

- Promote employee safety by providing direction and support for the Electrical Safety Program.
- Promote consistency in how electrical tasks are completed safely within the various facilities of campus.
- Place an emphasis on controlling electrical hazards through the application of engineering and design controls.

- Provide arc flash analyses required by this program, as needed and during equipment replacement or upgrading.

b) Environmental Health and Safety (EHS)

- Periodically review and update this written program.
- Provide or coordinate general training for work units on the content of this program.
- Evaluate the overall effectiveness of the electrical safety program on a periodic basis.
- Assist work units in the implementation of this program.
- Provide or assist in the task of specific training for electrical work qualifications.
- Maintain training documentation through recordkeeping. Training documentation will contain content of the training, each employee's name and dates of training. Documentation of training shall be made when the employee demonstrates proficiency in the work practices involved.
- Evaluate work being performed and determine compliance with this program (through inspections conducted on at least an annual basis).

c) Supervisors

- Promote electrical safety awareness to all employees.
- Ensure employees comply with ALL provisions of the electrical safety program.
- Ensure employees receive training appropriate to their assigned electrical tasks and maintain documentation of such training.
- Maintain documentation of Qualified Electrical Workers in Training and the Qualified Electrical Worker they work with while undergoing on-the-job training.
- Develop and maintain a listing of all qualified employees under their supervision.
- Ensure employees are provided with and use appropriate protective equipment.
- During supervision, evaluate work being performed and that each employee is complying with the safety-related work practices.

d) Employees

- Follow the work practices described in this document, including the use of appropriate protective equipment and tools.
- Attend all required training.
- Immediately report any concerns related to electrical safety to supervision.

4. Training

Workers near energized, or potentially energized electrical circuitry of fifty (50) volts to ground or greater, shall be trained in energized electrical safe work practices and procedures and retrained annually.

a) Requirements – Qualified Electrical Worker

Employees must receive training in avoiding the electrical hazards associated with working on or near exposed energized parts prior to performing energized electrical work. Such training will be provided when the employee is initially assigned to the job and refresher training will be provided every year, or anytime an employee is not complying with the safety-related work practices. Additional training must be provided

anytime new technology; new equipment or when conditions change that necessitates a change in the normal work practices.

The following items are to be included in the training of Qualified Electrical Workers:

- Demonstrate a working knowledge of the National Electrical Code.
- The Lockout/Tagout Training Program 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 electric equipment.
- Perform 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 Appendix A and the corresponding voltages to which the qualified electrical worker will be exposed.
- Selection and use of proper work practices, personal protective equipment, tools, insulating and shielding materials and equipment for working on or near energized parts.
- Basic Cardio Pulmonary Resuscitation (CPR)
- Automatic External Defibrillator (AED)
- Contacting emergency personnel and basic first aid

b) Documentation of Training and Experience

Documentation of training shall be maintained by each shop and EHS. Experience received by Qualified Electrical Workers must be documented. Documentation is necessary to demonstrate that individuals have met the training and experience requirements for the types of work being performed.

5. Basic Electrical Safety Principles for Energized Condition

Basic electrical safety principles should be followed anytime an energized electrical condition exists.

- **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 before beginning.
- **Identify the hazards.** Conduct a job hazard analysis. 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 personal protective equipment (PPE) and tools.
- **Anticipate problems.** If it can go wrong, it might. Make sure the proper PPE and tools are immediately available and worn by employees.
- **Obtain training.** Make sure all involved employees are qualified electrical workers with appropriate training for the job.

6. 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.
- Portable cord and plug connected equipment and extension cords must be visually inspected before use on any shift for external defects such as loose parts, deformed and missing pins, or damage to outer jacket or insulation, and for possible internal damage such as pinched or crushed outer jacket. Any defective cord or cord-and-plug-connected equipment must be removed from service.
- Extension cords must be of the three-wire type. Extension cords and flexible cords must be designed for hard or extra hard usage (for example, types S, ST, and SO). The rating or approval must be visible.
- Job-made extension cords are forbidden.
- Personnel performing work on renovation or construction sites using extension cords or where work is performed in damp or wet locations must be provided, and 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 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. It is recommended that the receptacle be replaced with a three-prong outlet. 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 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 (for example, 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 properly locked into the connector.
- Lamps for general illumination 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 GFCI's.
- Extension cords are considered to be temporary wiring, and must also comply with the section on "Requirements for Temporary Wiring" in this program.

7. Requirements for Temporary Wiring

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

- Ground-fault protection (e.g., ground-fault circuit interrupters, or GFCI) must be provided on all temporary-wiring circuits, including extension cords, used on construction sites.
- In general, all equipment and tools connected by cord and plug must be grounded. Listed or labeled double insulated tools and appliances need not be grounded.
- Feeders must originate 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 earth returns may be used for the wiring of any temporary circuit.
- Receptacles must be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit must contain a separate equipment-grounding conductor, and all receptacles must be electrically connected to the grounding conductor.
- 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 the fixed wiring, where run through holes in walls, ceilings or floors, where run through doorways, windows or similar openings, where attached to building surfaces, or where concealed behind building walls, ceilings or floors.
- Suitable disconnecting switches or plug connects must be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.
- 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 cord 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.

8. Wet or Damp Locations

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

9. Working on De-energized Equipment (Electrically Safe Conditions)

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
- Approved insulating mats
- Electrically insulated shoes should be worn
- Safety glasses must be worn
- The required Arc Flash PPE must also be worn

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

- Identify all sources of power to the equipment. Check applicable up-to-date drawings, diagrams, and identification tags.
- Remove the load current, and then open the disconnecting devices for each power source.
- Where possible, visually verify that blades of disconnecting devices are fully open or that drawout-type circuit breakers are fully withdrawn.
- Apply lockout/tagout devices in accordance with a formal, written policy (Appendix F).
- Test each phase conductor or circuit part with an adequately rated voltage detector to verify that the equipment is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Check the voltage detector before and after each test to be sure it is working.
- 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 "Working On or Near Energized Equipment."

10. Lockout/Tagout Program

The University of Alabama has developed a separate written lockout/tagout program which is provided in Appendix F. The program covers planning for locating and labeling energy sources, identifying employees at risk, how and by whom the equipment is de-energized, releasing of stored energy, verifying that the circuit is de-energized and can't be restarted, voltage testing, grounding requirements, shift changes, coordination with other jobs in progress, a procedure for keeping track of all involved personnel, applying and removing lockout/tagout devices, return to service, and temporary re-energizing for testing/positioning. Lockout/tagout procedures should be developed for each machine or piece of equipment that will require servicing. Each person who could be exposed to electric energy must be involved in the lockout/tagout process.

After de-energizing, each employee at risk should apply an individual lockout/tagout device to each source of electric energy. Pushbuttons or selector switches cannot be used as the only way to de-energize. A lockout device is a key or combination lock with a tag that can be attached to a disconnecting device to prevent the re-energizing of the equipment being worked on without removal of the lock. The lockout device should have a way of identifying whose lock it is. Individual lockout devices with the employee name and picture on them are preferred. That employee must be the only person who has the key or combination for the lockout device they install, and that employee should be the only person to remove the lock after all work has been completed. A tagout device is a tag and a way to attach it that can withstand at least 50 pounds of force. Tagout devices should be used alone only when it is not possible to install a lockout device. The tag used in conjunction with a lockout or tagout device must have a label prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.

Before beginning work, each involved employee must verify through testing that all energy sources have been de-energized. Electric lockout/tagout procedures should be coordinated with all other site procedures for controlling exposure to electric energy and other types of energy sources.

a) **Individual qualified-employee control procedure**
   For minor servicing, maintenance, inspection, and so on, on plug-connected equipment, work may be done without attaching lockout/tagout devices if the plug is next to where the employee is working, is always easy to see, the equipment is never left alone while being serviced, and a lockable cover is placed over the plug with a lock installed on the cover.

b) Complex lockout/tagout procedures

Special procedures are needed when there is more than one energy source, crew, craft, location, employer, way to disconnect, or lockout/tagout procedure - or work that lasts beyond one shift. In any of these cases, one qualified person should be in charge of the lockout/tagout procedure with full responsibility for ensuring all energy sources are under lockout/tagout and to account for all people on the job. Appendix F contains an in-depth written plan addressing the specific details of lockout/tagout.

c) Removal of lockout/tagout devices

Lockout and tagout devices should be removed only by the person installing them. If work is not completed when the shift changes, workers arriving on shift should apply their locks before departing workers remove their locks.

d) Return to service

Once work is completed and lockout/tagout devices removed, tests and visual inspection must confirm that all tools, mechanical restraints, electric jumpers, shorts, and grounds have been removed. Only then is it safe to re-energize and return to service. Employees responsible for operating the equipment and needed to safely re-energize it should be out of the danger zone before equipment is re-energized.

e) Temporary release

If the job requiring lockout/tagout is interrupted for testing or positioning equipment, follow the same steps as in "**Return to service**" (above).

11. Working on or Near Energized Equipment

Working on live circuits means actually touching energized parts. Working near live circuits means working close enough to energized parts to pose a risk even though work is 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

Supervisors should adopt standard written procedures and training for these common tasks. For instance, 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).

a) Energized Electrical Work Permit For 240 Volts And Higher

If live parts are not placed in an electrically safe condition, work to be performed shall be considered energized electrical work, and shall be performed accompanied by written permit only. A copy of The University of Alabama Energized Electrical Work Permit can be found in the Appendix D of this document. The intent of this permit is to ensure that all appropriate safety precautions are taken prior to starting energized electrical work. Work related to testing, troubleshooting, and voltage measuring may be completed without a permit provided appropriate

safe work practices and PPE are used. The permit must be originated by a qualified electrical worker. Energized Work Permits shall be submitted to the appropriate supervisor. The permit must be posted in an appropriate location where the energized work is taking place for the duration of the task.

b) Approach Distances To Live Parts

Safe approach distances to live parts can be determined by referring to Appendix A.

- 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 with 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 is approved by the supervisor.
  2) Use PPE suitable for working near exposed lived 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 permit with proper written work procedures and justifying the need to work that close.
  3) Conduct a risk analysis.
  4) Have (2) and (3) approved by the appropriate supervisor.
  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.

Use PPE appropriate for working near exposed live parts and rated for the voltage and energy level involved.

When working on de-energized the parts, but still inside the flash protection boundary or nearby live exposed parts.

- If the parts cannot be de-energized, barriers such as insulated blankets must be used to protect against accidental contact or PPE must be worn.
- Employees shall not reach blindly into areas that might contain exposed live parts.

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

12. Equipment Labeling

The NEC requires switchboards, panel boards, industrial control panels, and motor control centers 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 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 the personnel before examination, adjustment, servicing, or maintenance of the equipment.
- Labels shall be either of the 2 examples (or similar) shown in Figure 1 of Appendix B
- The first DANGER label shall be used when information is not presently available. This is the minimum NEC requirement.
- The DANGER label should remind a qualified worker who intends to open the equipment for analysis or work:
  1) Electric arc flash hazard exists
  2) Turn off all power before opening
  3) Follow all requirements of NFPA 70E for safe work practices and wear appropriate personal protective equipment (PPE) for the specific hazard.
- The second DANGER label shall be used when a qualified electrical worker or electrical engineer determines the values of the shock and flash protection information.
- 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 energized equipment.

a) Implementation Procedures

- Immediately place danger labels on equipment required to be labeled by NEC.
- Until an arc flash hazard analysis can be made, a qualified Electrical Worker using Appendix C, Hazard/Risk Category Selections, shall for each situation:
  1) Determine the hazard/risk category
  2) Determine the use of V-rated gloves
  3) V-rated gloves are gloves rated and tested for the maximum line-to-line voltage upon work will be done.

- Determine the use of V-rated tools. V-rated tools are tools rated and tested for the maximum line-to-line voltage upon work will be done.
- The University of Alabama shall complete an arc flash hazard analysis as required by NFPA 70E.
  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 completed for all new electrical system installations.

13. Arc Flash Hazard Analysis

An arc flash hazard analysis includes the following:

- Collect data on the facility's power distribution system.
- Arrangement of components on a one-line drawing with nameplate specifications of every device.
- Lengths and cross-section area of all cables.
- Contact the electric utility for information including the minimum and maximum fault currents that can be expected at the entrance to the facility.
- Conduct a short circuit analysis followed by a coordination study.
- Feed the resultant data into the NFPA 70E or IEEE Standard equations.
- These equations produce the necessary flash protection boundary distances and incident energy to determine the minimum PPE requirement.
- 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.)

14. Personal Protective Equipments

a) General Requirements

Employees working in areas where there are potential electrical hazards must be provided with and use personal protective equipment (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 of which an employee may be exposed. Each shop shall provide electrical protective equipment (Arc Flash Gear) required by this program. Such equipment shall include Arc Flash apparel (until a full arc flash hazard analysis is made), eye

protection, head protection, hand protection, insulated footwear, and face shields where necessary.

b) Protective Clothing Characteristics

Category	Cal/cm2	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

- 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 without arc rating shall not be used for electrical work. Safety glasses or goggles must always be worn underneath face shields.
- Additional illumination may be needed when using tinted face shields as protection during electrical work.
- Electrical Protective Equipment must be selected to meet the criteria established by the American Society of Testing and Materials (ASTM) and by the America 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 circuit. Tools and handling equipment should be replaced if the insulating capability is decreased due to damage. Protective gloves must be used when employees are working with exposed electrical parts above fifty (50) volts.

- Fuse handling equipment (insulated for circuit voltage) must be used to remove or install fuses when the fuse terminals are energized. 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 from shock, burns, or other electrical injuries while that person is working near exposed energized parts that might be accidentally contacted or where dangerous electric heating or arcing might occur.

c) Flame-Resistant Apparel & Under Layers

- 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 under layers beneath FR apparel.
- Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric under layers next to skin. (An incidental amount of elastic used on non-melting fabric underwear or socks shall be permitted).
- FR 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.

d) 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.
- 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 my cause damage.

- No repairs to rubber insulating equipment shall be attempted without the approval of the shop supervisor.

e) 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 for 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.

15. Access Limiting Equipment

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.

16. Approach Boundaries

Observing a safe approach distance from exposed energized parts is an effective means of maintaining electrical safety.

- Safe approach distances to live parts can be determined by referring to Appendix A. This appendix can be used to identify the Limited, Restricted, and Prohibited Approach Boundaries associated with various system voltages.
- Unqualified persons may only cross the Limited Approach Boundary when they are under the direct supervision of a qualified person.

17. Vehicular and Mechanical Equipment

Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a clearance of 10 feet is maintained. If the voltage is greater than 50 kV then the clearance shall be increased 4 inches for every 10kV over that voltage. When work must be performed near overhead lines, the lines shall be de-energized and grounded, or other protective measures shall be provided before work is started.

- If the lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the electric circuits involved to de-energize and ground them.
- If protective measures, such as guarding, isolating or insulating are provided, these precautions shall prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools or equipment

a) Elevated Equipment

Where any vehicle or mechanical equipment structure will be elevated near energized overhead lines, they shall be operated so that the Limited Approach Boundary distances are maintained.

b) Equipment Contact

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

- The employee is using protective equipment rated for the voltage.
- The equipment is located so that no un-insulated part of the structure (that portion of the structure that provide a conductive path to employees on the ground) can come closer to the line than permitted in Limited Approach Boundaries.

c) Equipment Grounding

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

APPENDIX A

Safe Approach Distances and Diagram Appendix A – Safe Approach Distances and Diagram

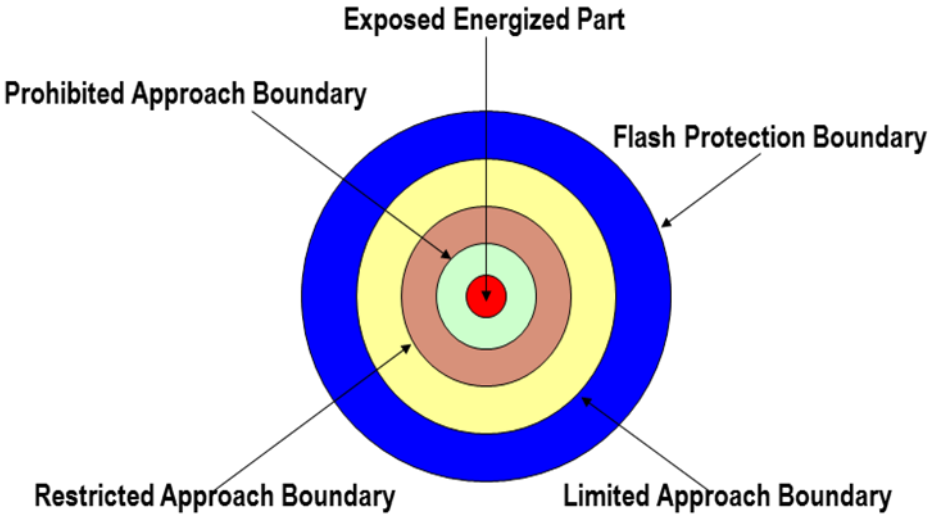

Table 130.4(C)(a) Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection for Alternating-Current Systems (All dimensions are distance from energized electrical conductor or circuit part to employee.)

(1)	(2)	(3)	(4)	(5)
	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder	Prohibited Approach Boundary[b]
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part		
<50 V	Not specified	Not specified	Not specified	Not specified
50 V–300 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 V–750 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)	25 mm (0 ft 1 in.)
751 V–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)	0.2 m (0 ft 7 in.)
15.1 kV–36 kV	3.0 m (10 ft 0 in.)	1.8 m (6 ft 0 in.)	0.8 m (2 ft 7 in.)	0.3 m (0 ft 10 in.)
36.1 kV–46 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)	0.4 m (1 ft 5 in.)
46.1 kV–72.5 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 3 in.)	0.1 m (2 ft 2 in.)
72.6 kV–121 kV	3.3 m (10 ft 8 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 4 in.)	0.8 m (2 ft 9 in.)
138 kV–145 kV	3.4 m (11 ft 0 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)	1.0 m (3 ft 4 in.)

Table 130.4(C)(a) *Continued*

(1)	(2)	(3)	(4)	(5)
	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder	
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part		Prohibited Approach Boundary[b]
161 kV–169 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.3 m (4 ft 3 in.)	1.1 m (3 ft 9 in.)
230 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)	1.7 m (5 ft 8 in.)	1.6 m (5 ft 2 in.)
345 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	2.8 m (9 ft 2 in.)	2.6 m (8 ft 8 in.)
500 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.6 m (11 ft 10 in.)	3.5 m (11 ft 4 in.)
765 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)	4.9 m (15 ft 11 in.)	4.7 m (15 ft 5 in.)

Note: For arc flash boundary, see 130.5(A).

[a] For single-phase systems, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.

[b] See definition in Article 100 and text in 130.4(D)(2) and Annex C for elaboration.

[c] This term describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

Table 130.4(C)(b) Approach Boundaries[a] to Energized Electrical Conductors or Circuit Parts for Shock Protection, Direct-Current Voltage Systems

(1)	(2)	(3)	(4)	(5)
	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder	
Nominal Potential Difference	Exposed Movable Conductor[b]	Exposed Fixed Circuit Part		Prohibited Approach Boundary
<100 V	Not specified	Not specified	Not specified	Not specified
100 V–300 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 V–1 kV	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)	25 mm (0 ft 1 in.)
1.1 kV–5 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.5 m (1 ft 5 in.)	0.1 m (0 ft 4 in.)
5 kV–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)	0.2 m (0 ft 7 in.)
15.1 kV–45 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)	0.4 m (1 ft 5 in.)
45.1 kV– 75 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 2 in.)	0.7 m (2 ft 1 in.)
75.1 kV–150 kV	3.3 m (10 ft 8 in.)	3.0 m (10 ft 0 in.)	1.2 m (4 ft 0 in.)	1.0 m (3 ft 2 in.)
150.1 kV–250 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.6 m (5 ft 3 in.)	1.5 m (5 ft 0 in.)
250.1 kV–500 kV	6.0 m (20 ft 0 in.)	6.0 m (20 ft 0 in.)	3.5 m (11 ft 6 in.)	3.3 m (10 ft 10 in.)
500.1 kV–800 kV	8.0 m (26 ft 0 in.)	8.0 m (26 ft 0 in.)	5.0 m (16 ft 5 in.)	5.0 m (16 ft 5 in.)

[a] All dimensions are distance from exposed energized electrical conductors or circuit parts to worker.

[b] This terms describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

APPENDIX B
Labels
Warning Labels

The following example label shall be affixed to industrial control panels (every enclosure that may contain exposed energized conductors or components) immediately:

The following label is an example of a label to be affixed to industrial control panels after arc flash hazard analysis has been completed:

Each of the above labels is available through the State MRO contract with Grainger.

APPENDIX C
Hazard/Risk Category Selections

Table 130.7(C)(15)(a) Hazard/Risk Category Classifications and Use of Rubber Insulating Gloves and Insulated and Insulating Hand Tools-Alternating Current Equipment (Formerly Table 130.7(C)(9)

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Panelboards or other equipment rated 240 V and below Parameters: Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 19 in.			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	0	N	N
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	0	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard	1	Y	Y
Panelboards or other equipment rated > 240 V and up to 600 V Parameters: Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 30 in.			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	1	N	N
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	Y	N
Work on energized electrical conductors and circuit parts, including voltage testing	2	Y	Y
Remove/install CBs or fused switches	2	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	0	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard	2	Y	Y
600 V class motor control centers (MCCs) Parameters: Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 53 in.			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	1	N	N

(continues)

Table 130.7(C)(15)(a) ***Continued***

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch or starter operation with enclosure doors open	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	2	Y	Y
Application of temporary protective grounding equipment, after voltage test	2	Y	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the motor control center	2	Y	Y
600 V class motor control centers (MCCs) Parameters: Maximum of 42 kA short circuit current available; maximum of 0.33 sec (20 cycle) fault clearing time; minimum 18 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 165 in.			
Insertion or removal of individual starter "buckets" from MCC	4	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
600 V class switchgear (with power circuit breakers or fused switches) and 600 V class switchboards Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.5 sec (30 cycle) fault clearing time; minimum 18 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 233 in.			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	2	N	N
CB or fused switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	2	Y	Y

Table 130.7(C)(15)(a) ***Continued***

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Insertion or removal (racking) of CBs from cubicles, doors open or closed	4	N	N
Application of temporary protective grounding equipment after voltage test	2	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	2	N	N
Other 600 V class (277 V through 600 V, nominal) equipment Parameters: Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance (except as indicated) Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 53 in.			
Lighting or small power transformers (600 V, maximum)			
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	2	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2	Y	Y
Application of temporary protective grounding equipment, after voltage test	2	Y	N
Revenue meters (kW-hour, at primary voltage and current)—insertion or removal	2	Y	N
Cable trough or tray cover removal or installation	1	N	N
Miscellaneous equipment cover removal or installation	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2	Y	Y
Application of temporary protective grounding equipment, after voltage test	2	Y	N
Insertion or removal of plug-in devices into or from busways	2	Y	N
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.2 sec (12 cycle) fault clearing time; minimum 36 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 422 in.			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	3	N	N
Contactor operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Contactor operation with enclosure doors open	2	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	3	Y	Y

(continues)

Table 130.7(C)(15)(a) *Continued*

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Insertion or removal (racking) of starters from cubicles, doors open or closed	4	N	N
Application of temporary protective grounding equipment, after voltage test	3	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	3	N	N
Insertion or removal (racking) of starters from cubicles of arc-resistant construction, tested in accordance with IEEE C37.20.7, doors closed only	0	N	N
Metal clad switchgear, 1 kV through 38 kV Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.2 sec (12 cycle) fault clearing time; minimum 36 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 422 in.			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	3	N	N
CB operation with enclosure doors closed	2	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB operation with enclosure doors open	4	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	2	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	4	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open or closed	4	N	N
Application of temporary protective grounding equipment, after voltage test	4	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	3	N	N
Opening voltage transformer or control power transformer compartments	4	N	N
Arc-resistant switchgear Type 1 or 2 (for clearing times of < 0.5 sec with a perspective fault current not to exceed the arc-resistant rating of the equipment) Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.2 sec (12 cycle) fault clearing time; minimum 36 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 422 in.			
CB operation with enclosure door closed	0	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	0	N	N

Table 130.7(C)(15)(a) *Continued*

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Insertion or removal of CBs from cubicles with door open	4	N	N
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	2	Y	Y
Insertion or removal (racking) of ground and test device with door closed	0	N	N
Insertion or removal (racking) of voltage transformers on or off the bus door closed	0	N	N
Other equipment 1 kV through 38 kV Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.2 sec (12 cycle) fault clearing time; minimum 36 in. working distance Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 422 in.			
Metal-enclosed interrupter switchgear, fused or unfused			
Switch operation of arc-resistant-type construction, tested in accordance with IEEE C37.20.7, doors closed only	0	N	N
Switch operation, doors closed	2	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	3	N	N
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade)	2	Y	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examination, in open area	2	Y	N

Y = Yes (required). N: No (not required).

Notes:

(1) Rubber insulating gloves are gloves rated for the maximum line-to-line voltage upon which work will be done.

(2) Insulated and insulating hand tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done, and are manufactured and tested in accordance with ASTM F 1505, *Standard Specification for Insulated and Insulating Hand Tools*.

(3) The use of "N" does not indicate that rubber insulating gloves and insulated and insulating hand tools are not required in all cases. Rubber insulating gloves and insulated and insulating hand tools may be required by 130.4, 130.8 (C) (7)(a), and 130.8(D)(1).

(4) For equipment protected by upstream current limiting fuses with arcing fault current in their current limiting range (½ cycle fault clearing time or less), the hazard/risk category required may be reduced by one number.

(5) For power systems up to 600 V the arc flash boundary was determined by using the following information: When 0.03 second trip time was used, that indicated MCC or panelboard equipment protected by a molded-case circuit breaker. Working distance used was 18 in. (455 mm). Arc gap used was 32 mm for switchgear and 25 mm for MCC and protective device type 0 for all. When 0.33 or 0.5 second trip time was used, that indicated a LVPCB (drawout circuit breaker) in switchgear. Working distance was 18 in. (455 mm). Arc gap used was 32 mm and protective device type 0 for all. All numbers were rounded up or down depending on closest multiple of 5.

(6) For power systems from 1 kV to 38 kV the arc flash boundary was determined by using the following information: No maximum values were given in the 2009 edition of NFPA 70E for short-circuit current or operating time. Two sets of equations were performed: 35 kA AIC and 0.2 second operating time and 26 kA AIC and 0.2 second operating time. 0.2 seconds was used by adding the typical maximum total clearing time of the circuit breaker to an estimated value for relay operation. This coincides with the IEEE 1584 values of 0.18 second operating time and 0.08 tripping time rounded off. A short-circuit current of 35 kA was used as a maximum (HRC-4 @ ~ 40 cal/cm^2) and 26 kA was used to compare the effects of lowering the short circuit current (HRC-4 @ ~ 30 cal/cm^2). Working distance used was 36 in. (909 mm), arc gap was 6 in. (455 mm), and protective device type 0 for all.

APPENDIX D

Energized Electrical Work Permit

ENERGIZED ELECTRICAL WORK PERMIT

(For Applications of 240 volts or greater)

1. Work Location: _____

2. Work order/project #: _____

3. Description of the work to be done: _____

_____

_____

_____

_____

_____

4. Check the following considerations when they apply:

☐ Work is within the restricted approach boundary and there is a work plan
☐ Work is within the prohibited approach boundary, it is very hazardous and there is a work plan
☐ Request to shut down equipment was made
☐ Conducted a shock hazard analysis
☐ Shock protection boundaries have been determined
☐ Flash hazard analysis has been made and the results are known
☐ Flash protection boundary has been determined
☐ Personal protective equipment including tools needed for the job have been determined and are available
☐ Unqualified persons are restricted from the work area
☐ Safe work practices that need to be employed have been considered
☐ Job can be done safely

_____ _____

(Signature, Electrically Qualified Person) (Date)

_____ _____

(Signature, Immediate Supervisor) (Date)

APPENDIX E
Electrical Safety Training Checklist

ELECTRICAL SAFETY TRAINING CHECKLIST			
TRAINING ITEM	**YES ☑**	**N/A ☑**	**COMMENTS**
SCOPE AND TRAINING			
1. All employees who work on, near or with premises wiring, wiring for connections to supply, other wiring, and installation of optical fiber cable along with electrical conductors have been trained as either qualified or unqualified workers.	❑	❑	
2. Unqualified person have been trained in and are familiar with any electrically related safety practices not covered by this standard but necessary for their safety.	❑	❑	
3. Qualified persons trained in and familiar with:			
a) Skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.	❑	❑	
b) Voltage determination.	❑	❑	
c) Clearance distances that must be maintained.	❑	❑	
d) Training conducted has been specific to the hazards to which the employee may or will be exposed and their particular job duties.	❑	❑	
SELECTION AND USE OF WORK PRACTICES			
1. Work practices used to prevent electric shock and other injuries address de-energized parts which may be energized.	❑	❑	
2. Work practices used to prevent electric shock and other injuries address exposure to energized parts.	❑	❑	
3. Procedure provided for work on or near exposed de-energized parts includes:			
a) Written procedures specific to the equipment or worksite.	❑	❑	
b) De-energizing equipment.	❑	❑	
c) Application of locks and tags.	❑	❑	

4. Working on or near exposed energized parts:				
a)	All employees near enough to be exposed to a hazard have been trained, and are aware of the practices that must be followed to protect them from the hazard.	❑	❑	
b)	Only qualified employees work on energized parts.	❑	❑	
c)	Overhead lines de-energized and grounded prior to working near them **or** other protective measures used.	❑	❑	
d)	Unqualified persons working near overhead lines are aware that they may not come approach, or use conductive objects closer than, 10 feet for lines up to 50 kV, or 10 feet plus 4 inches for every 10 kV over 50 kV.	❑	❑	
e)	Qualified persons has a working knowledge of the allowable approach distances of this program.	❑	❑	
f)	Vehicle and mechanical equipment operators understand that they must maintain:			
	i) A clear distance of 10 feet plus 4 inches for every 10 kV over 50 kV while working near energized overhead lines.	❑	❑	
	ii) A clear distance of 4 feet plus 4 inches for every 10 kV over 50 kV while in transit.	❑	❑	

	TRAINING ITEM	**YES** ☑	**N/A** ☑	**COMMENTS**
	iii) Insulating barriers are used and installed as required.	❑	❑	
	iv) Insulated aerial lift operated by a qualified person must comply with the separation distances.	❑	❑	
	v) Employees standing on the ground understand they may not contact the vehicle unless using protective equipment rated for the voltage or the equipment located so no un-insulated part can provide a conductive path to persons on the ground.	❑	❑	
g)	Illumination is provided at all worksites to assure safe work.	❑	❑	

h)	Protective shields and barriers provided and used for work in confined spaces to prevent contact with exposed energized parts.	❑	❑	
i)	All conductive materials such as pipes, rods, etc. are handled so as to prevent contact with exposed energized parts.	❑	❑	
j)	Conductive articles of clothing and jewelry such as watches, rings, etc. are not worn if they might contact exposed energized parts unless rendered nonconductive.	❑	❑	
k)	Portable ladders with nonconductive side rails are used when working near or on exposed energized conductors.	❑	❑	
l)	Housekeeping conducted only when exposed energized parts may not be contacted. Barriers provided and nonconductive cleaning materials used.	❑	❑	
m)	Only qualified persons allowed to defeat electrical interlocks on temporary basis while they work on equipment.	❑	❑	
USE OF EQUIPMENT				
1. Portable electric equipment such as cord-and-plug connected equipment, including flexible cords:				
a)	Handled in a manner to avoid damage.	❑	❑	
b)	Not used to raise or lower equipment.	❑	❑	
c)	Not fastened with staples or hung so as to damage insulation.	❑	❑	
d)	Visually inspected before each use on each shift.	❑	❑	
e)	Defective items removed from service and not used until rendered safe.	❑	❑	
f)	Plugs and receptacles mate properly.	❑	❑	
g)	Flexible grounding-type cords have a grounding conductor.	❑	❑	
h)	Grounding plug not defeated.	❑	❑	
i)	Adapters which interrupt grounding continuity not used.	❑	❑	
j)	Approved equipment used for work in conductive work locations (e.g. wet locations, etc.).	❑	❑	
k)	Locking-type connectors are properly secured after connection.	❑	❑	

TRAINING ITEM	YES ☑	N/A ☑	COMMENTS
ELECTRIC POWER AND LIGHTING CIRCUITS			
1. Only load rated switches or circuit breakers used as disconnecting means.	❑	❑	
2. Circuits not manually reenergized until it is determined that it is safe to do so.	❑	❑	
3. Over current protection of circuits not modified.	❑	❑	
TEST INSTRUMENTS AND EQUIPMENT			
1. Used by qualified persons only.	❑	❑	
2. Visually inspected before use.	❑	❑	
3. If circuit tested is over 600 volts, nominal, test instrument tested for proper operation before and immediately after the test.	❑	❑	
4. Test instrument rated for the circuit to be tested and appropriate for the environment.	❑	❑	
5. Electrical equipment capable of igniting flammable or ignitable materials not used if present in the worksite.	❑	❑	
SAFEGUARDS FOR PERSONNEL PROTECTION			
1. Protective equipment used when there is exposure to potential electrical hazards.	❑	❑	
2. Protective equipment maintained in safe and reliable condition and tested and inspected as required.	❑	❑	
3. Protective equipment protected from damage during use.	❑	❑	
4. Approved electrically rated hardhats used as needed to protect head from electric shock or burns.	❑	❑	
5. Safety glasses or goggles used as needed to protect eyes or face when there is a danger of arcs, flashes or flying objects.	❑	❑	
6. Approved gloves worn that are appropriate for the hazard present	❑	❑	
7. Insulated tools or handling equipment used when conductors may be contacted.	❑	❑	
8. Insulated fuse handling equipment used to remove or install fuses when terminals are energized.	❑	❑	
9. Ropes and hand lines used near energized parts are nonconductive and are protected from moisture.	❑	❑	

10. Protective shields, barriers or insulating materials are used to protect employees working near exposed energized parts.	❑	❑	
ALERTING TECHNIQUES			
1. Safety signs and tags used when necessary to warn employees about electrical hazards.	❑	❑	
2. Barricades used with safety signs when necessary to prevent or limit employee access to work areas with un-insulated energized conductors or parts.	❑	❑	
3. Attendants stationed as needed to warn when signs or barricades are not sufficient to prevent unauthorized access.	❑	❑	

Name of Trainer:		Date:
EMPLOYEE NAME	Employee Name	Employee Name

APPENDIX F

Lockout/Tagout Procedures
Hazardous Energy Control Procedures
Lockout/Tagout

1. Purpose and Scope

Effective hazardous energy control procedures will protect employees during machine and equipment servicing and maintenance where the unexpected energization, start up or release of stored energy could occur and cause injury, as well as while working on or near exposed de-energized electrical conductors and parts of electrical equipment. Hazards being guard against include being caught in, being crushed by, being struck by, being thrown from, or contacting live electrical circuits/parts.

The procedure herein established will insure that machines and equipment are properly isolated from hazardous or potentially hazardous energy sources during servicing and maintenance and properly protect against re-energization.

While any employee is exposed to contact with parts of fixed electrical equipment or circuits that have been de-energized, the circuits energizing the parts shall be locked out and tagged.

Only when disconnecting means or other devices are incapable of being locked out, and until lockout capability is provided, will a tagout procedure (without lockout), be utilized.

2. Enforcement

Any employee who fails to follow these procedures will face disciplinary action in accordance with UA policies and procedures.

3. Definitions

Definitions are provided to clarify terms and provide additional resource information.

Authorized employee – A person who locks out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance that exposes him/her to potentially hazardous energy.

Affected employee - An employee whose job requires him/her to operate /use a machine or equipment or work in an area in which servicing or maintenance is being performed under lockout.

Energy isolating device – A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selectors switches, and other control circuit type devices are not energy isolating devices.

Other employee - An employee whose work operations are or may be in an area where energy control procedures may be utilized.

4. Rules

All employees shall follow the outlined rules below:

- Locks, chains, wedges, or other hardware which are needed for lockout procedures shall be provided by The University.
- Lockout devices shall be singularly identified. They shall be the only devices used for controlling energy and shall not be used for other purposes.
- The lockout devices shall indicate the identity of the employee who has applied the devices.
- All machines/equipment shall be locked out to protect against accidental or inadvertent operation when such operation could cause injury to personnel. Lockout will also apply when working on or near exposed de-energized electrical circuits / parts.
- No employee shall attempt to operate any switch, valve, or other energy -isolating device which is locked out.
- Each lockout device shall only be removed by the employee who applied the device. The only exception is specified in Section VI Removal of Lockout Devices.

5. Lockout Procedures and Techniques

a) Preparation for Shutdown

In preparation for lockout, an initial survey must be made to locate and identify all energy isolating devices to be certain which switch, valve, or other energy isolating devices apply to the machine / equipment to be locked out. More than one energy source (electrical, hydraulic, pneumatic, chemical, thermal, or others) may be involved. Before an authorized or affected employee turns off a machine or piece of equipment, the authorized employee must have knowledge of the type and magnitude of the energy to be controlled, and the methods or means to control the energy.

b) Machine or Equipment Shutdown

All affected employees shall be notified that a lockout system is to be utilized and the reason for it, before the controls are applied. If the machine or equipment is operating, shut it down by normal stopping procedure (depress stop button, open toggle switch, etc.).

c) Machine or Equipment Isolation

Physically locate and operate the switch, valve, or other energy isolating devices so that the equipment is isolated from its energy sources and apply adequate hardware.

Lockout Device Application

Authorized employees shall lockout the energy isolating devices with assigned individual locks. Lockout devices shall be applied so that they will hold the energy isolating devices in a "Neutral" or "Off' position.

d) Stored Energy

All stored or residual energy in rams, flywheels, springs, pneumatic, or hydraulic systems, etc. shall be blocked or dissipated. If there is a possibility of accumulation of stored energy, verification of isolation must be continued until servicing or maintenance is completed.

e) Verification of Isolation

Prior to starting work on machines or equipment that have been locked and after ensuring that no personnel are exposed, the authorized employee shall operate the push button or normal operating controls to verify that the appropriate equipment or machine has been de-energized and make certain it will not operate. CAUTION: Return Operating Controls to the "Neutral" or "Off' Position after the Test. The machine / equipment is now locked out. Servicing or maintenance may now occur.

6. Removal of Lockout Devices

After the servicing and/or maintenance has been completed and before the lockout devices are removed and energy is restored, the sequence of activities listed below shall be completed by the authorized employee(s) who applied the device.

- Clear the machine or equipment of tools and materials. Make sure all of the machinery or equipment components are operationally intact.
- Employees should be removed from the machine or equipment and safely positioned clear of the area.
- Additionally all affected employees must be notified that the lockout devices are being removed.
- Remove the lockout device.

If the authorized employee who applied the lock is not available (not at the facility), the employee's supervisor shall take the above listed steps prior to removal of lockout devices after he has made reasonable efforts to contact the authorized employee(s) to inform him/her that his/her lockout device has been removed and this supervisor must ensure that the authorized employee(s) know that the lockout device has been removed before he/she resumes work at the facility.

In some cases it may be necessary to temporarily restore energy to a machine or piece of equipment to test and/or reposition the machine. Remember to follow all outlined procedures for lockout and the removal of the lockout devices. See Section V for Lockout Procedures and Techniques and then refer to Section VI prior to Removal of Lockout Devices.

7. Additional Requirements

a) Group Lockout

In the proceeding steps, if more than one individual is required to lockout machines and/or equipment (group lockout), the following procedures shall be implemented to provide protection to all employees.

- A primary authorized employee will be designated and responsible for the number of people working under the protection of the group lockout device. The primary authorized employee will ascertain the exposure status of the individual member

participating in the group lockout to ensure continuity of protection for each individual. In addition, this primary authorized employee will be responsible for notifying affected employees before and after lockout procedures are performed.
- Each authorized employee will place his/her own personal lockout device on the energy isolating device(s).
- When an energy- isolating device cannot accept multiple locks, a multiple lockout system must be used.

b) Shift or Personnel Changes

If a lockout procedure will extend into the following shift, the authorized employee who originally placed the lock will remove it and it will immediately be replaced with the lock of the authorized employee who is to continue the repair or maintenance on that equipment or machine for the following shift.

8. Cord and Plug Connected Equipment

If servicing or maintenance is performed on cord and plug connected equipment the following procedure shall be performed to protect employees:

- Unplug equipment from its electrical socket.
- Place a lockable cover over the plug and a lock on the plug cover during machine / equipment servicing or maintenance.

9. Outside Contractors

If outside contractors perform servicing or maintenance that requires lockout, the responsible UA department or area shall:

- Inform the outside contractor of our company's lockout procedures and supply them with a copy.
- Obtain and review a copy of the outside contractor's lockout procedures.
- Ensure that UA employees understand and comply with the responsibilities and prohibitions of the outside contractor's lockout procedure.

10. Training

Authorized employees shall receive training covering:

- Recognition of hazardous energy sources.
- Types and magnitude of hazardous energy in the workplace.
- Methods, devices, and procedures used to lockout, verify lockout, and otherwise control hazardous energy on all pieces or types of equipment (including cord and plug connected equipment).
- Procedures for removing locks and returning a machine or piece of equipment to operation.
- Transfer of lockout responsibilities.
- Group lockout procedures.

Affected and all "other" employees shall receive training so that they are able to:

- Recognize when energy control procedures are being implemented, and
- Understanding the purpose of the procedures and the importance of not attempting to start up or use the machine / equipment that have been locked out.

11. Retraining

Authorized and affected employees shall receive retraining in proper application of lockout procedures when there is a change in:

- Job assignment(s) that expose an authorized employee to new hazards or lockout procedures.
- Machines, equipment, or processes that present a new hazard or require modified lockout procedures.
- Energy control procedures for a piece or type of equipment.
- Or when it becomes known that an employee incorrectly performs lockout procedures.
- Or at least annually

12. Periodic Inspections

- An inspection of the energy control procedures will be conducted annually.
- Energy control procedures for each machine or type of machine must be inspected.
- The inspection shall include a review of lockout responsibilities with each individual authorized to lockout the machine / equipment.
- The person who performs the inspection must be authorized to perform the lockout procedures being inspected. The inspector cannot, however, review his/her own use of lockout procedures.
- Any deviations or inadequacies identified shall be immediately addressed.

13. Tagout Procedures

- When a disconnecting means or other energy isolating device is incapable of being locked out, a tagout system shall be utilized. A tag used without a lock, shall be supplemented by at least on additional safety measure that provides a level of safety equivalent to that obtained by use of a lock such as opening an additional disconnecting device, removal of an isolating circuit element, blocking of a controlling switch or the removal of a valve handle to reduce the likelihood of inadvertent energizing.
- Only tags furnished by The University of Alabama shall be used.
- All applicable employees shall be trained in the use and limitations of tags.
- All employees must be able to understand the hazard warning written on the tags such as: DO NOT START, DO NOT OPEN, DO NOT CLOSE, DO NOT ENERGIZE, DO NOT OPERATE.
- If tagout is used all other lockout rules and procedures apply. Refer to previous sections for direction on Lockout Procedures and Techniques, Removal of Lockout Devices, Additional Requirements, etc. for more information