



# **Electrical Safe Work Practices Program**

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## **Introduction**

Electricity is a serious workplace hazard, capable of causing both employee injury and property damage. It is the policy of Berea College to protect all employees, students, and other personnel from potential electrical hazards. This will be accomplished through compliance with the work practices described in this policy along with effective application of engineering controls, administrative controls, and the use of personal protective equipment.

This Electrical & Arc Flash 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 conditions applies:

- De-energizing introduces additional or increased hazards. Examples of additional or increased hazards would include deactivation of emergency alarm systems or shutdown of hazardous location ventilation systems.
- De-energizing is not possible due to equipment design or operational limitations. Examples of this situation would include testing and troubleshooting of electrical circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.
- Live parts are operating at less than 50 volts to ground and there is no increased exposure to electrical burns or to explosion due to electrical arcs.

## **PURPOSE**

This program has been established in order to:

- Ensure the safety of employees who may work on or near electrical systems.
- Ensure that employees understand and comply with safety standards related to electrical safety.
- Ensure that employees follow uniform practices during the completion of electrical work.

# **RESPONSIBILITIES**

## **Environmental Health and Safety**

- Periodically review and update this written program.
- Provide or coordinate general training for shops on the content of this program.
- Evaluate overall effectiveness of the Electrical & Arc Flash Safety Program on a periodic basis.

## **Facilities Mgmt.: Supervisors**

- Determine the applicability of the Electrical & Arc Flash Safety Program to activities conducted within their respective areas.
- Responsible for the implementation of the Electrical & Arc Flash Safety Program within their areas.
- Ensure employees comply with all provisions of the Electrical & Arc Flash Safety Program.
- Ensure employees receive training appropriate to their assigned electrical tasks and maintain documentation of such training.
- Develop and maintain a listing of all qualified employees in their areas.
- Ensure employees are provided with and use appropriate protective equipment.

## **Facilities Mgmt.: Employees**

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

## DEFINITIONS

The following terms are defined in order to allow a better understanding of this program.

- **Arc rating:** The maximum incident energy resistance demonstrated by a material (or a layered system of materials) prior to “breaking open” or at the onset of a second-degree skin burn. This rating is assigned to electrical protective clothing and is normally expressed in calories per square centimeter (cal/cm<sup>2</sup>).
- **Electrically safe work condition:** A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with Berea College policy, tested to ensure the absence of voltage, and grounded if determined necessary.
- **Energized:** Electrically connected to or having a source of voltage.
- **Exposed (as applied to live parts):** Capable of being inadvertently touched or suitably guarded, isolated, or insulated.
- **Flash hazard analysis:** A study to investigate a worker’s potential exposure to arc-flash energy, conducted for the purpose of injury prevention and the determination of safe work practices along with appropriate levels of PPE.
- **Flash protection boundary:** An 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.
- **Flash suit:** A complete FR clothing and equipment system that covers the entire body, except for the hands and feet. (Such a suit typically includes pants, jacket, and a “bee-keeper” style hood fitted with a face shield).
- **FR apparel:** Flame-resistant apparel; describes a broad category of clothing designed to protect employees from electrical arc events during completion of energized tasks.
- **Incident energy:** The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units used to measure incident energy is calories per square centimeter (cal/cm<sup>2</sup>).
- **Limited approach boundary:** An approach limit at a distance from an exposed live part within which a shock hazard exists.

- **Live parts:** Energized conductive components.
- **Prohibited approach boundary:** An approach limit at a distance from an exposed live part within which work is considered the same as making contact with the live part.
- **PPE:** An acronym for “Personal Protective Equipment”.
- **Qualified person:** One who has skills and knowledge related to the construction and operation of the electrical equipment and installation and has received training on the hazards involved.
- **Restricted approach boundary:** An approach limit at a 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.
- **Unqualified person:** Any person who does not meet the definition of a qualified person.
- **Working near (live parts):** Any activity within a Limited Approach Boundary.
- **Working on (live parts):** Coming in contact with live parts via tools, probes, test equipment, hands, feet, or other body parts regardless of the level of PPE worn.

## **TRAINING**

- Employees who are exposed to an electrical hazard that is not reduced to a safe level by the installation must be trained.
- The level of electrical safety training provided is dependent on whether the employee is classified as a “qualified person” or “unqualified person”.
- A “qualified person” shall be trained and knowledgeable in all of the following topics:
  - Construction and operation of equipment on which work is assigned.
  - Skills and techniques necessary to distinguish exposed energized parts from other parts of electrical equipment.
  - Skills and techniques necessary to determine the nominal voltage of exposed live parts.

- The approach distances specified in this document and the corresponding voltages to which the qualified employee will be exposed.
- The process necessary to determine the degree and extent of electrical hazards along with the PPE and job planning necessary to perform the task safely.
- A person can be considered qualified with respect to certain equipment and methods but unqualified for others.
- An “**unqualified person**” shall be trained in the inherent hazards of electricity and any related work practices that are necessary for their safety.
- Training must be provided before the employee is assigned duties that involve work near or on electrical systems.
- Each supervisor and Environmental Health and Safety shall maintain a record of all electrical training provided to their employees along with a listing of all employees classified as qualified persons.

## **WORKING ON OR NEAR LIVE PARTS**

Energized electrical work **under 600 volts does not require a work permit** if the employee performing the work follows the guidelines in this program (e.g. wears Indura work uniform and cotton undershirt, uses appropriate PPE, etc.). *Reference National Fire Protection Association’s standard NFPA 70E.*

### **Energized Electrical Work Permit – Energized *work over 600 volts***

- If live parts are not placed in an electrically safe condition, work to be performed shall be considered energized electrical work and will be performed by written permit only.
- A copy of the Berea College Energized Electrical Work Permit can be found in Appendix A 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 is to be originated by the individual requesting that the energized work be completed. (This will normally be the supervisor of the employee who will be completing the work).

- All Energized Electrical Work Permits should be submitted to the Electrical Superintendent or his/her designee and/or Manager of Safety for approval.
- The permit must be posted in the area where the energized work is taking place for the duration of the task.
- Energized electrical work permits must be kept on file by the supervisor upon completion of the task.

### **Approach Boundaries to Live Parts**

- Observing a safe approach distance from exposed energized parts is an effective means of maintaining electrical safety. As the distance between an individual and live parts increases, the potential for an electrical injury decreases.
- Safe approach distances will be determined for all tasks in which approaching personnel are exposed to live parts.
- Safe approach distances to fixed live parts can be determined by referring to Appendix B, "Approach Boundaries to Live Parts for Shock Protection". 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.
- **Qualified persons** may not cross or take any conductive object closer than the Restricted Approach Boundary unless one of the following conditions apply:
  - The **qualified person** is insulated or guarded from the live parts and no uninsulated part of the qualified person's body crosses the Prohibited Approach Boundary.
  - The live parts are insulated from the qualified person and from any other conductive object at a different potential.



Crossing the Prohibited Approach Boundary is considered the same as making contact with energized parts. Qualified persons may only cross this boundary when all of the following precautions have been taken:

- The qualified person has specific training to work on energized parts.
- The qualified person uses PPE appropriate for working on energized parts, which are rated for the voltage and energy level involved.

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### **Other Precautions for Personnel Activities**

- 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. keys must be removed and placed in a secure location.
- 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, metallined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.
- When an employee works in a confined space or enclosed space (such as a manhole or vault) that contains exposed live parts, the employee shall obtain a Confined Space Work Permit and 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.

## **PERSONAL PROTECTIVE EQUIPMENT**

### **General Requirements**

- Employees working in areas where electrical hazards are present shall be provided with, and shall use, protective equipment (Arc Flash Gear) that is designed and constructed for the specific body part to be protected and for the work to be performed.

Berea College will provide electrical protective equipment (Arc Flash Gear) required by this program at no cost to employees. Such equipment shall include an Arc Flash rated apparel, eye protection, head protection, hand protection, insulated footwear, and face shields where necessary. Berea College is not responsible for providing under layers of clothing.

- All protective equipment shall be maintained in a safe, reliable condition by the employee to whom it is issued.

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- Employees shall wear nonconductive head protection whenever there is a danger of a 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 nonconductive protection for the face, neck, and chin whenever there is danger of injury from exposure to electric arcs or flashes or from flying objects resulting from an electrical explosion.
- Employees shall wear protective equipment for the eyes and face 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 and arm injury due to contact with live parts or possible exposure to arc flash burn.
- If an employee is wearing shoes other than hard-soled type (tennis shoes are not considered hard soled), he/she must wear dielectric overshoes, which will be provided by the College.
- Face shields without an arc rating will 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.

### **Flash Protection Boundary**

- Personal protective equipment shall be provided to and used by all employees working within the “Flash Protection Boundary”.
- For systems that are 600 volts or less the Flash Protection Boundary shall be a minimum of four feet. The formula in Appendix C can be used to determine the exact Flash Protection Boundary for systems over 600 volts.
- For systems that are above 600 volts, the Flash Protection Boundary shall be determined through engineering analysis.

The specific protective equipment to be worn within the Flash Protection Boundary can be determined by either of the following two methods:

- Complete a flash hazard analysis that determines the incident exposure energy of each employee. Appropriate protective clothing can then be selected based on the calculated exposure level.

- - Determine the hazard level of the task by referring to NFPA 70E Table 130.7 (C) (9) (a), “Hazard/Risk Category Classifications” (Appendix D of this document). This table also indicates whether voltage-rated gloves and/or tools need to be used. Once the hazard level of the task has been determined, the required PPE can then be ascertained from NFPA 70E Table 130.7 (C) (10), “Protective Clothing and PPE Matrix”. (Appendix E of this document).
  - Facilities Management shall develop and maintain a listing of the specific PPE requirements for each energized electrical task conducted by their employees using the form found in Appendix F of this document.

### **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 FR 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 shirtsleeves 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 the skin. (An incidental

amount of elastic used on non-melting fabric underwear or sock 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.

### **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 the use, the insulating material shall be protected by an outer covering of leather or other appropriate material.
- Rubber insulating equipment must be tested according to the schedule contained in Appendix G.
- 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.

### **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.
- Insulated tools shall be protected from damage and degradation of the integrity of the insulation.

- 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.

## **ALERTING TECHNIQUES**

- 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.
- Barricades, such as plastic fencing, must be in place if workers have to leave energized parts exposed over 600 volts.
- If signs and barricades do not provide sufficient protection, and attendant will be assigned to warn and protect pedestrians. The primary duty of the attendant shall be to keep unqualified persons 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.

## **CONTRACT EMPLOYEES**

- Safety programs used by contractors on Berea College jobsites must meet or exceed all applicable guidelines of this Safety Program.
- Contractors will be required to comply with applicable Safety and Health regulations such as OSHA, NFPA, EPA, etc.

# Electric Arc Flash Protection

## Standard Operating Procedure

It is the goal of Berea College to control the arc flash hazard, which occurs during the maintenance of electrical building components throughout campus. Standard operating procedures will eliminate or control arc flash events to reduce the hazard to employees.

To reduce the potential for arc flash occurrences, the following standard operating procedures will be applied:

1. De-energize all circuits before performing any maintenance on them.
2. Ensure that all possible sources of supply are found and open disconnecting devices for each source.
3. Apply Lockout/Tagout devices in accordance with Facilities Management Lockout/Tagout procedures.
4. Test voltage on each conductor to verify that it is de-energized.
5. Apply grounding devices where stored energy or induced voltage could exist or where de-energized conductors could contact live parts.

If it is necessary to work on energized equipment; the following procedures will be applied:

1. Establish boundaries keeping those not involved with the work ten feet away.
2. Use insulated tools.
3. Consider using insulated floor mats.
4. Wear safety glasses.
5. Wear voltage rated gloves.
6. Wear hard-soled leather work shoes or dielectric overshoes.
7. Wear appropriate arc flash protection.
  - a. Voltages 50-120- standard cotton work shirt and cotton pants.

- b. Voltages 120-600 category 2 arc flash coat over standard uniform, low voltage gloves, hardhat with arc flash shield and earplugs.
- c. Voltage above 600-category 4 arc flash coat, pants high voltage gloves, switching hood and earplugs.

## **Exposure Control Program (lockout/Tagout)**

This program is written to ensure all power sources have been identified and the means to control such energy has been established by the college to prevent the unexpected energizing, start up or release of stored energy.

1. Energy control procedures must be written unless there is the existence of the following:
  - A.** The equipment has no potential for stored energy
  - B.** The equipment has a single energy source.
  - C.** Isolation and lockout of one energy source completely deactivates the equipment
  
  - D.** The equipment is isolated from energy sources and is locked out.
  - E.** Single lockout devices achieve a lockout condition.
  - F.** No other hazards are created.
  - G.** The lockout device is under exclusive control of authorized employee performing maintenance.

The most efficient method to safeguard against accidental activation of machinery is by utilizing the "LOCKOUT/TAGOUT" procedure. By locking out and /or tagging off power sources, unauthorized use of the machine or equipment is prevented and thus locking out and / or tagging off power sources minimizes injuries incurred through accidental activation.

A lockout is simply a lock placed upon a machine or electrical circuit to keep the power supplies from being activated while repairs are being done. Lockout procedures are especially effective in preventing injuries to maintenance or repair personnel due to the fact that they are most frequently injured by sudden and unexpected activation of machinery while repairs are being completed.

Lockouts do not refer only to protection against electrical hazards. Other types of energy can cause accidents as well and employees can be protected through the use of lockouts. These sources include hydraulic, pneumatic, steam, chemical energy, and vehicles, such as forklifts, which can be left unattended or on inclines.

Tagging the machine/equipment should follow the locking out of machine/equipment. Tags that are marked with the words "DANGER DO NOT OPERATE" on one side, will have an area on the back for the employee responsible for locking out the machine/equipment to sign, with the date and time, and department name. Locks and tags are provided for by the company, as direct supervisors will responsible for direct issuance to employees, and for notifying their supervisor of the need for additional locks and tags.

All employees who perform a lockout/tagout procedure must be given the correct authorization to do so. Authorized employees are those employees who have received training on the steps



that are required to safely lockout or tagout a machine/equipment. (A listing of authorized employee is provided in Appendix B) Any employee, who performs a lockout/tagout procedure but is not authorized to do so, is putting themselves and their fellow workers into grave danger and will be subject to disciplinary action equivalent to the company disciplinary policy.

The correct procedures that all employees are expected to follow when preparing for locking out or tagging out a machine or piece of equipment is:

1. Make a survey to locate and identify all isolating devices to be certain which switch(s), valve(s) or other energy devices apply to the equipment to be locked or tagged out.
2. Make sure that ALL energy sources to a specific piece of equipment have been identified. Usually machines have more than one energy source (electrical, mechanical, or others).

The correct sequence that all authorized employees are expected to follow when locking out or tagging out is as follows:

1. Notify all affected employees that a servicing or maintenance is required on a machine or equipment and that the machine or equipment must be shut down and locked out and/ or tagged out to perform the servicing or maintenance.
2. It is the authorized employee's responsibility to know the type and magnitude of energy that the machine or equipment utilizes and to understand the hazards associated with the machine or equipment and the methods to control such energy. If the authorized employee is unsure as to the energy type and magnitude, the hazards associated with that machine or equipment or how to control the energy then that employee should contact his or her direct supervisor for assistance.
3. If the machine or equipment is operating, shut down by the normal stopping procedures (depress button, open toggle switch, close valve, etc.).
4. Operate the switch, valve, or other energy isolating device(s), so that the equipment is isolated from its energy source(s). Stored energy (such as that in springs, elevated machine members, rotating flywheels, hydraulic systems, and air gas, steam, or water pressure, etc.) must be dissipated or restrained by methods such as repositioning, blocking, bleeding down, etc., as required by that certain machine or switch.
5. Lockout and/or tagout the energy isolating devices with assigned individual lock(s) or tag(s). If the maintenance task requires group lockout (a group of employees working in the same machine or equipment), each should have a lock applied at each point. Only the person applying the lock will have a key to that lock. This assures that, as different team members complete their tasks and remove their locks, remaining members are still fully protected from hazardous energy.
6. After ensuring that no personnel are exposed, and as a check on having disconnected the energy sources, operate the push button or other normal operating controls to make certain the equipment will not operate.
7. If the equipment will not operate, it is now locked out or tagged out. If the equipment continues to operate, return to step # 3 to determine if all steps were followed correctly. If problem persists, contact your supervisor.

8. If a change in shift or personnel occurs, lockout/tagout protection must still occur. A full status report will be given to the on-coming shift or personnel, and they will apply their own lock and/or tag to the energy-isolating device.

The correct measures all employee's are expected to follow when restoring machines or equipment to normal operating production operations is as follows:

1. After the servicing and/or maintenance are complete and equipment is ready for normal production operations, check the area around the machines or equipment to ensure that no one is exposed.
2. After all tools have been removed from the machine or equipment, guards have been reinstalled and employees are in the clear, remove all lockout or tagout devices. Operate the energy isolating devices to restore energy to the machine or equipment.
3. Notify affected employees that the servicing or maintenance is completed and the machine is ready for use.
4. The employee who applied the device shall remove each lockout or tagout device from each energy-isolating device.

## **Training**

Training of Berea College employees regarding the lockout/tagout program is the most important part of this program. Employees will be trained on the following:

1. ALL employees and new employees will be educated as to the purpose and use of an energy control procedure and as to what a tagout signifies, why the machine is locked and/or tagged out, and what to do when encountering a tag or lock on a switch or a device they wish to operate. Since any given employee may encounter a lockout or tag or lockout, employees who are covered under this program will be provided training as to the general understanding of lockout safety.
2. Before machine shutdown, the AUTHORIZED employee must know the type and magnitude of energy to be isolated and how to control it. Each machine or type of machine will have a written lockout procedure.
3. Retraining will be provided to employees whenever an employee is reassigned to a different area or machine; or when written procedures change.
4. Additional retraining shall also be conducted whenever a periodic inspection reveals, or whenever the respective supervisor has reason to believe that there are deviations from or inadequacies in the employee's knowledge or use of the energy control procedures.
5. The retraining shall establish employee proficiency and introduce new or revised control methods and procedures as necessary.

6. When outside contractors are brought on site, they will be informed of Berea College lockout procedures.
7. It will be the responsibility of the outside contractor to be familiar with Berea College lockout-tagout procedures and ensure that all contracting personnel understand and comply with Berea College energy control procedures.
8. All authorized employees will be trained in the proper sequence of locking out machines or equipment.

**If a tagout system is used, employees will also be trained in the following limitations of tags:**

1. Tags are essentially warning devices affixed to energy isolating devices, and do not provide the physical restraint on those devices that is provided by a lock.
2. When a tag is attached to an energy isolating means, it is not to be removed without the authorization of the authorized person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated.
3. Tags must be legible and understandable by all authorized employees, affected employees, and all other employees whose work operations are or may be in the area, in order to be effective.
4. Tags and their means of attachment must be made of materials, which will withstand the environmental conditions encountered in the workplace.
5. Tags may evoke a false sense of security, and their meaning needs to be understood as part of the overall energy control program.
6. Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use.

## **Cord and Plug Equipment and Tools**

### **Lockout Tagout Procedure**

Procedure Number: **02** Equipment:

**All cord and plug equipment and tools.**

Step 1: **Verify** identity of energy sources and isolation devices. Energy source is 110 volt electric. No isolation device. Cord and plug. This unit might have a starting capacitor.

Step 2: **Notify** the affected employees.

Step 3: **Shut down**. Turn off the switch on the unit. Wait until all mechanical parts have stopped moving.

Step 4: **De-activate**. Unplug the equipment from the outlet.

Step 5: **Lock out**. Not necessary to lockout the equipment if it is going to be under your control the entire time. If you must leave the area for any reason, then you must attach your lock and tag to a plug lock on the plug.

Step 6: **Dissipate**. Dissipate the capacitor if the unit has one.

Step 7: **Verify**. Verify that the unit is deenergized by attempting to start the equipment using the on/off switch.

Step 8: **Perform** the service.

Step 9: **Ensure** that nonessential items have been removed and that the equipment is intact.

Step 10: **Check the work area** to ensure that all employees have been safely positioned or removed from the area.

Step 11: **Verify** that the controls are in neutral or off position.

Step 12: **Remove** the lockout devices and reenergize the machine or equipment.

Step 13: **Notify** affected employees.

## Appendix A: Approach Boundaries to Live Parts for Shock Protection

(All dimensions are distance from live part to employee)

Nominal System Voltage (phase to phase)	Limited Approach Boundary (fixed circuit parts)	Restricted Approach Boundary (includes inadvertent movement adder)	Prohibited Approach Boundary
Less than 50V	Not specified	Not specified	Not specified
50V to 300V	3 feet, 6 inches	Avoid contact	Avoid Contact
301V to 750V	3 feet, 6 inches	1 foot	1 inch
751V to 15 kV	5 feet	2 feet, 2 inches	7 inches
Over 15 kV or movable conductor	See NFPA 70 E Table 130.2 (C)		

- Limited Approach Boundary:** Distance from an exposed live part within which a shock hazard exists. An unqualified person may not cross this boundary unless they are continuously escorted by a qualified person.
- Restricted Approach Boundary:** 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. This boundary may only be crossed by a qualified person who is safely insulated or guarded from the live parts.
- Prohibited Approach Boundary:** Distance from an exposed live part within which work is considered the same as making contact with the live part. This boundary may only be crossed by a qualified person who has specific training to work on energized parts; has obtained an approved Energized Electrical Work Permit; and uses PPE appropriate for working on energized parts which are rated for the voltage and energy level involved. (Note: A permit is not required for work related to testing, troubleshooting, and voltage measuring).

- **Flash Protection Boundary (not listed in table):** Distance from exposed live parts within which a person could receive a second-degree burn if an electrical arc flash were to occur. This boundary may only be crossed by a qualified person wearing the appropriate PPE. For systems that are 600 volts or less, the Flash Protection Boundary shall be a minimum of four feet. An analysis must be performed to determine the Flash Protection Boundary for systems that are above 600 volts.

## Appendix B: Formula for Calculation of Flash Protection Boundary

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$$

OR

$$D_c = [53 \times MVA \times t]^{1/2}$$

Where:

**D<sub>c</sub>** = Distance in feet from an arc source for a second-degree burn

**MVA<sub>bf</sub>** = Bolted fault capacity available at point involved (in mega volt-amperes)

**MVA** = Capacity rating of transformer (mega volt-amperes). For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by 1.25

**t** = Time of arc exposure (in seconds)

Examples:

1. Transformer 1000kVA = 1.0 mVA, and breaker trip setting instantaneous of 0.1 seconds

$$D_c = [53 \times 1 \times 0.1]^{1/2}$$

$$D_c = (5.3)^{1/2}$$

$$D_c = 2.3 \text{ feet}$$

2. Transformer 1000kVA = 1.0mVA, and breaker trip setting at short time delay of 0.5 seconds

$$D_c = [53 \times 1 \times 0.5]^{1/2}$$

$$D_c = (26.5)^{1/2}$$

$$D_c = 5.1 \text{ feet}$$

Flash Protection Boundary increases with breaker trip settings.

## Appendix C: Hazard/Risk Category Classifications

Task (Assumes equipment is energized, and work is done within the Flash Protection Boundary)	Hazard/Risk Category	V-rated Gloves	V-rated Tools
Panelboards Rated 240 V and Below			
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 parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N
Panelboards or Switchboards Rated > 240 V and up to 600 V (with molded case or insulated case circuit breakers)			
CB or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	N	N
Work on energized parts, including voltage testing	2 (*)	Y	Y

### PPE Requirements can be found in Appendix E

#### Additional Information:

- V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
- V-rated Tools are tools that are rated and tested for the maximum line-to-line voltage upon which work will be done.
- 2(\*) means that a double-layer switching hood and hearing protection are required for this task in addition to the other Hazard/Risk Category requirements of Appendix E.
- Y = Yes (required)
- N = No (not required)

#### Notes:



- 25kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
- For <10kZ short circuit current available, the hazard/risk category required may be reduced by one number.

## Appendix D: Personal Protective Equipment Matrix

Protective Clothing and Equipment	Protective Systems for Hazard/Risk Category						
	Hazard/Risk Category Number	-1 <sup>(3)</sup>	0	1	2	3	4
Non-melting (according to ASTM F 1506-00) or Untreated Natural Fiber							
a. T-shirt (short-sleeve)	X				X	X	X
b. Shirt (long-sleeve)		X					
c. Pants (long)	X	X	X <sup>(4)</sup>	X <sup>(6)</sup>	X	X	X
FR Clothing <sup>(1)</sup>							
a. Long-sleeve shirt			X	X	X <sup>(9)</sup>	X	X
b. Pants			X <sup>(4)</sup>	X <sup>(6)</sup>	X <sup>(9)</sup>	X	X
c. Coverall			<sup>(5)</sup>	<sup>(7)</sup>	X <sup>(9)</sup>	<sup>(5)</sup>	<sup>(5)</sup>
d. Jacket, parka, or rainwear			AN	AN	AN	AN	AN
FR Protective Equipment							
a. Flash suit jacket (multilayer)							X
b. Flash suit pants (multilayer)							X
c. Head protection							
1. Hard hat			X	X	X	X	X
2. FR hard hat liner					AR	AR	AR
d. Eye protection							
1. Safety glasses	X	X	X	AL	AL	AL	AL
2. Safety goggles				AL	AL	AL	AL
e. Face and head area protection							
1. Arc-rated face shield or hood				X <sup>(8)</sup>			
2. Flash suit hood					X	X	X
3. Hearing protection (ear canal inserts)				X <sup>(8)</sup>	X	X	X
f. Hand protection							
Leather gloves			AN	X	X	X	X
g. Foot protection							
Leather work shoes			AN	X	X	X	X
<b>PPE Arc Flash Gear Required</b>	<b>N/R</b>	<b>N/R</b>	<b>4cal</b>	<b>8cal</b>	<b>25cal</b>	<b>40cal</b>	<b>40cal</b>

**Hazard categories up to 2 will require 11 calorie protection.**

**Hazard categories over 2 will require 40 calorie protection.**

**AN = As needed    AR = As required    AL = Select one in group    X = Minimum required**

### **Notes:**

- (1) See Table 130.7 (C) (11). Arc rating for a garment is expressed in cal/cm<sup>2</sup>.
- (2) If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfy this requirement.
- (3) Hazard/Risk Category Number "-1" is only defined if determined by Notes 3 or 6.
- (4) Regular weight (minimum 12oz/yd<sup>2</sup> fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants.

The FR pants used for Hazard/Risk Category 1 shall have a minimum arc rating of 11 cal.

- (5) Alternate is to use FR coveralls (minimum arc rating of 11 cal) instead of FR shirt and FR pants.
- (6) If the FR pants have a minimum arc rating of 11 cal, long pants of non-melting or untreated fiber are not required beneath the FR pants.
- (7) Alternate is to use FR coveralls (minimum arc rating of 11 cal) over non-melting or untreated natural fiber pants and Tshirt.
- (8) A face shield with a minimum arc rating of 11 cal, with wrap around guarding to protect not only the face, but also the forehead, ears and neck is required.
- (9) Alternate is to use two sets of FR coveralls (the inner with a minimum arc rating of 4 cal and outer coverall with a minimum arc rating of 5) over non-melting or untreated natural fiber clothing, instead of FR coveralls over the FR shirt and FR pants over non-melting or untreated natural fiber clothing.



## Appendix F: Inspection Schedule for Rubber Insulating Equipment

Type of Equipment	When to Test
Rubber insulating line hose	Upon indication that insulating value is suspect
Rubber insulating covers	Upon indication that insulating value is suspect
Rubber insulating blankets	Before first issue and every 12 months thereafter (*)
Rubber insulating sleeves	Before first issue and every 12 months thereafter (*)
Rubber insulating gloves	Before first issue and every 6 months thereafter (*)

(\*) – If the insulating equipment has been electrically tested but not issued for service, it may not be placed into service unless it has been electrically tested within the previous 12 months.