# Purpose

This program establishes work standards to reduce 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 ensures that only qualified electrical workers perform electrical work and defines how to safely perform this work.

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# Responsibilities

The responsibilities of the employer and employee regarding the Electrical Safety Program are outlined in the main Safety Manual document.

# Priority

The information contained in this document describes the procedures necessary to reduce the risk of injury related to working with electrical systems. In order to prevent or eliminate electrical hazards, employees shall lockout all energy sources prior to installation, repair, or replacement of equipment. Energy is not only electrical but may also be pneumatic, hydraulic, steam, heat, chemical, mechanical etc.

This Electrical Safety Program specifically reinforces the need to fully comply with the Lockout / Energy Control procedure; however, it is recognized there may be situations (e.g., troubleshooting) in which energy remains in order to complete the task.

# References

NFPA 70E, 2018 Ed.

OSHA 1910.331 – 1910.335, 1910.147

# Organization

This document is organized to coordinate with the articles of the 2018 edition NFPA 70E: Standard for Electrical Safety in Workplace. The table below identifies the specific sections of this document that correspond to the articles of the NFPA 70E.

|  |  |  |
| --- | --- | --- |
| Electrical Safety Program | Reference Standard | Article |
| Section 7 | NFPA 70E 2018 Ed. | 110 |
| Section 8 | 120 |
| Section 9 | 130 |
| Section 10 | 200 |
| Section 11 | 300 |

# General Requirements for Electrical Work

## Electrical Safety Program

### General

The Electrical Safety Program implements and documents the overall electrical safety system that directs the activity of employees to manage the risk associated with electrical hazards. This program is implemented as part of the overall occupational health and safety management system outlined in the Safety Manual.

### Awareness and Self-Discipline

This program is designed to provide awareness of electrical hazards for all employees, provide employees a systematic process to perform electrical work safely and to perform risk assessments of all electrical work, including the self-discipline required when exposed to electrical hazards.

### Electrical Safety Program Principles

The electrical safety program principles include, but are not limited to, the following:

1. Inspecting and evaluating the electrical equipment
2. Maintaining the electrical equipment’s insulation and enclosure integrity
3. Planning every job and documenting first-time procedures
4. De-energizing electrical systems prior to electrical work, if possible
5. Anticipating unexpected events
6. Identifying the electrical hazards and reducing the associated risk
7. Protecting employees from shock, burn, blast, and other hazards due to the working environment
8. Using the right tools for the job
9. Assessing people’s abilities
10. Auditing the principles of this program

### Electrical Safety Program Controls

The electrical safety program controls include, but are not limited to, the following:

1. These electrical safety program principles, procedures, training requirements and audit requirements ensure employee awareness of hazards, able to properly perform hazard assessments and perform work in a consistently safe manner.
2. To perform electrical work, including establishing an Electrically Safe Work Condition, employees are required to be Qualified Electrical Workers.
3. Electrical Safety Task Analysis are to be performed and documented for all electrical work, which include identification of the hazards, methods for eliminating or reducing those hazards, and control of the associated risk for those hazards that cannot be eliminated.
4. Every electrical conductor or circuit part is considered energized until proven otherwise.
5. De-energizing an electrical conductor or circuit part and making it safe to work on is, in itself, a potentially hazardous task.

### Electrical Safety Program Procedures

The Electrical Safety Task Analysis (ESTA) is the fundamental building block of the electrical safety program procedures and must be completed by a Qualified Electrical Worker. The ESTA accomplishes the majority of the elements outlined in NFPA 70E and is mandatory for all work with exposures to electrical hazards.

The Complex Lockout Procedure and the Energized Work Permit extend the ESTA for additional hazards and allow for more complete analysis and documentation of higher risk tasks. An alternative form to the ESTA, the Electrical Lab Project Assessment form, is utilized for small scale experiments to be performed by Student Qualified Electrical Workers.

Section 7.2 outlines the qualification process for Qualified Electrical Workers and Student Qualified Electrical Workers.

Hierarchy of Electrical Safety Program Procedures

### Risk Assessment Procedure

There exist three main components of the risk assessment procedure implemented as part of this program:

* **Safety System or Facility Wide Risks** – assessed and addressed via the Safety Steering Committee’s Risk Register. This includes identification of overall system health, present and future potential hazards, specific hazards associated with all work, not just electrical, within the facility, and any audit findings not in compliance with the system. For example, the facility wide Arc Flash Risk Assessment falls within this category of risks.
* **Project Specific Risks** – assessed and addressed by individual project managers through a risk management strategy approved by the Safety Steering Committee. The risk management strategy provides a check list that includes identification of project specific risks and definition of required mitigation actions applicable during the life-time of the project (e.g. critical lift plans required, updates to arc flash hazard analysis, electrical protection and coordination studies, critical projects tasks that require a Safety Task Analysis, etc.). As part of research and development activities, the QEW(s) most familiar with project specific risks (i.e., subject matter expert) shall perform the risk assessment.
* **Task Specific Risks** – assessed and mitigated by using the Electrical Safety Task Analysis (ESTA) by a Qualified Electrical Worker (QEW). The ESTA form provides the procedure requirements to assess and document the risks associated with specific electrical work tasks. The QEW training program provides the employee with the competencies required to assess and mitigate hazards associated with performing electrical work.

All three components of the risk assessment procedure address risk mitigation in reference to the hierarchy of controls:

1. Elimination
2. Substitution
3. Engineering Controls
4. Awareness
5. Administrative Controls
6. Personal Protective Equipment

Additionally, it is noted that Elimination, Substitution and Engineering Controls are the most reliable methods of hazard mitigation but it is acknowledged that Awareness, Administrative Controls and Personal Protective Equipment are commonly required for specific hazards and tasks.

This safety program uses a task driven procedure for risk assessment and mitigation and utilizes the Electrical Safety Task Analysis form to document this procedure. The Electrical Safety Task Analysis form shall be completed by a Qualified Electrical Worker prior to any electrical work being performed at the facility.

### Job Safety Planning and Job Briefing

The Electrical Safety Task Analysis (ESTA) shall be used for job safety planning and job briefing before starting each job that involves exposures to electrical hazards and shall be completed by a qualified electrical worker.

The ESTA is a three-part form used to assist the QEW through the job planning, job briefing, and simple lockout ESWC processes and document required information. The ESTA should not be solely relied upon for the risk assessment and management. Additional forms, such as the Energized Work Permit or Complex Lockout form, may be required to adequately address the electrical hazards for a particular job or task.

The Electrical Lab Project Assessment form is a combination of the ESTA, Energized Work Permit and Complex Lockout form and is designed to address the specific work and hazards associated with student electrical projects. The Electrical Lab Project Assessment form may be used as a substitute for these forms.

The electrical safety program procedure is defined by the Electrical Safety Task Analysis form and is used to evaluate and assess the following:

1. Purpose of the task
2. Qualification and number of employees to be involved
3. Identification of hazards and assessment of risks of the task
4. Limits of approach
5. Safe work practices to be used
6. Personal protective equipment (PPE) requirements
7. Insulation materials and tools to be used
8. Special precautionary techniques

In preparation of the Electrical Safety Task Analysis, the following items should be consulted as needed to properly address the hazards and risks:

1. Electrical single-line diagrams
2. Equipment details
3. Sketches or photographs of unique features
4. Other available reference data

Job Briefings use the SAFE Conversation Brief using the following principles:

1. **Summarize** – Review the job being performed, hazards, personnel involved, tools, equipment, and necessary protective equipment. Identify critical job steps. (A critical job step is an action that is unrecoverable and if performed incorrectly could cause harm to people, equipment, the environment, or quality)
2. **Anticipate** – What are the error traps? (Work stress, high workload, time pressure, imprecise communication, vague or incorrect guidance, overconfidence, first time or infrequent task, first day working after several days off, 30 minutes after waking up or a meal, crew harmony, etc.)
3. **Foresee** – What is the worst thing that can happen that could lead to injury, equipment damage, or testing setback? How could that happen?
4. **Evaluate** – What defenses are in place?
5. **Stop Work Criteria** - A significant change occurs affecting the safety which is outside of procedures, parameters, or processes. For example, equipment response not as expected, conditions are not as expected, work scope deviation is needed, work environment change, condition change, whenever uncertainty exist or clarification is needed, etc.

### Incident Investigation

The process and procedure for incident investigations is detailed in [SOP-060-EIC Reporting Systems and Incident Investigations](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/SOP-060-EIC%20Reporting%20Systems%20and%20Incident%20Investigations.docx).

### Auditing

All auditing requirements for this program are outlined in the main safety manual document.

 The audits performed of this Electrical Safety Program shall include:

1. Electrical Safety Program audit conducted at an interval not to exceed 3 years
2. Field Work Audits conducted at an interval not to exceed 1 year per Qualified Electrical Worker
3. Lockout Program and Procedure audit to be performed by a Qualified Electrical Worker at an interval not to exceed 1 year and shall cover at least one lockout in progress.

All audits required in this program shall be documented.

## Training and Qualification

### Electrical Safety Training

The EIC Electrical Safety program incorporates three basic levels of training that is dictated by the risks and hazards associated with different types of work.

#### Basic Electrical Safety Training

Basic Electrical Safety Training is required for all EIC employees and all students, staff and faculty of Clemson University that will perform any work at the EIC that could potentially expose them to electrical hazards.

#### Qualified Electrical Worker

All employees at the EIC performing work on electrical systems above 50V must complete the Qualified Electrical Worker process outlined in 7.2.2 and 7.2.2.1

#### Student Qualified Electrical Worker

All students at the EIC performing electrical experiments above 50V must complete the Student Qualified Electrical Worker process outlined in 7.2.2 and 7.2.2.2.

Training documentation requirements are:

1. The employer shall document that each employee has received the training
2. Documentation shall be made when the employee demonstrates proficiency in the work practices involved.
3. Documentation shall contain the context of the training, each employee’s name and date of the training.

### Qualified Electrical Worker Process

There are two types of qualified electrical workers covered under this program, Qualified Electrical Workers (QEW) and Student Qualified Electrical Workers (SQEW). The QEW process is focused on qualifying an employee to work safely on all of the electrical equipment and hazards at the EIC. The SQEW process is focused on qualifying a student to work safely in the EIC laboratory environment

Both training programs share common elements regarding:

1. Prerequisite Training
2. Electrical Safety Program
	1. Risk Assessment and Job Planning Procedure
	2. Establishing an Electrically Safe Work Condition
	3. Test Instrumentation and Meters
	4. Shock Hazards
	5. Arc Flash Hazards

#### Qualified Electrical Worker

The qualification process involves training, theoretical and practical examinations to establish an employee as a Qualified Electrical Worker. The process is outlined in [F-050-EIC Staff Qualified Electrical Worker](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/F-050-EIC%20Staff%20QEW%20Qualification.docx) form. Each employee designated as needed to be a Qualified Electrical Worker will have a record of their progress kept in their training records. The qualification process requires a series of knowledge interviews signed off by a Qualified Electrical Worker and a practical demonstration of safe work procedures.

The Qualified Electrical Worker process distinguishes between the different hazards, risks and controls in working on systems and specific equipment below 1000V nominal and above 1000V nominal, and thus qualifies employees on the categories of equipment in both voltage categories.

The qualification process of Qualified Electrical Workers incorporates the common elements outlined above and the following additional categories:

1. Equipment Specific <1000V
	1. Required practical to achieve initial qualification status
2. Equipment Specific >1000V
	1. Required practical for work on systems >1000V

#### Student Qualified Electrical Worker

The Student Qualified Electrical Worker process is a limited version of the Qualified Electrical Worker process designed for student access to the laboratory and to perform small scale experiments. The Student Qualified Electrical Worker process is outlined in [F-050-EIC Student Qualified Electrical Worker](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/F-051-EIC%20Student%20QEW%20Qualification%20.docx) form.

The qualification process of Student Qualified Electrical Workers incorporates the common elements outlined above and the following additional categories:

1. Laboratory Specific Equipment
	1. Required practical to achieve initial qualification status
2. Electrical Lab Project Assessment
	1. Project assessments for shock hazards and arc flash
	2. Lockout specific requirements for laboratory experiments

### Lockout Procedure Training

All EIC employees are required to have up to date Lockout procedure training at an interval not to exceed 3 years, unless the procedure is revised or when any form of noncompliance is observed.

### Emergency Response Training

All Qualified Electrical Workers are required to obtain and maintain First Aid and CPR training at an interval not to exceed 2 years.

Contact release methods training is required for all Qualified Electrical Workers and Student Qualified Electrical Workers at an interval not to exceed more than 1 year.

## Non-Employees, Visitors, and Contractors

All external visitors, contractors, or non-employees safety instructions are addressed in [SOP-61-EIC Non-Employees Visitors and Contractors](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/SOP-061-EIC%20Non-Employees%20Visitors%20and%20Contractors.docx).

As part of the non-employee and external contractor safety orientation and evaluation, the exposure of non-employees and external contractors to potential electrical hazards shall be assessed prior to being allowed to perform any work. Non-employees and external contractors shall be made aware of potential hazards they may be exposed to in performing work.

## Test Instruments and Equipment

### Testing

Only Qualified Electrical Workers shall perform tasks such as testing, troubleshooting and voltage measuring on electrical equipment operating at voltages equal to or greater than 50 volts.

Qualified Electrical Workers will have demonstrated the understanding to apply the rating and design of the instrumentation for the specific task and the capability to perform visual inspection and verification of operation.

### Rating

Test instruments, equipment and their accessories shall be:

1. Appropriately rated for circuits and equipment where they are utilized
2. Approved for the purpose
3. Used in accordance with any instructions provided by the manufacturer

### Design

Test instruments, equipment and their accessories shall be designed for the environment to which they will be exposed and for the manner in which they will be used.

### Visual Inspection and Repair

Test instruments and equipment and all the associated test leads, cables, power cords, probes and connections shall be visually inspected for external defects and damage before each use. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service and an Out of Service Tag shall be affixed to the device. No employee shall use tagged equipment until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.

### Operation Verification

When test instruments are used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts the test instrument shall be verified for proper operation on any known voltage source or a self-test verification capability both before and after the absence of voltage test is performed.

## Portable Cord and Plug Connected Equipment

This section applies to the use of cord- and plug-connected equipment, including extension cords.

### Handling and Storage

Portable equipment shall be handled and stored in a manner that will not cause damage. Flexible electric cords connected to equipment shall not be used for raising or lowering the equipment. Flexible cords shall not be fastened with staples or hung in such a fashion as could damage the outer jacket or insulation.

### Grounding-Type Equipment

All cord- and plug-connected equipment with grounding conductors shall not be altered in order to allow a use in a manner that was not intended by the manufacturer.

1. A flexible cord used with grounding-type utilization equipment shall contain an equipment grounding conductor.
2. Attachment plugs and receptacles shall not be connected or altered in a manner that would interrupt continuity of the equipment grounding conductor.
3. Adapters that interrupt the continuity of the equipment grounding conductor shall not be used.

### Visual Inspection and Repair

1. Frequency of Inspection – Before each use, portable cord and plug-connected equipment and extension cords shall be inspected before each use for external defects (such as loose parts or deformed and missing pins) and for evidence of possible internal damage (such as a pinched or crushed out jacket).
2. Defective Equipment – If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged items shall be removed from service and an Out of Service Tag shall be affixed to the cord at or near the plug. No employee shall use it until a person(s) qualified to perform the repairs and tests necessary to render the equipment safe has done so.
3. Proper Mating – When an attachment plug is to be connected to a receptacle, the relationship of the plug and the receptacle contacts shall first be checked to ensure that they are of mating configurations.

### Conductive Work Locations

Portable electric equipment used in highly conductive work locations (such as those inundated with water or other conductive liquids) shall be approved for those locations. In job locations where employees are likely to contact or be drenched with water or conductive liquids, ground-fault circuit-interrupter protection for personnel shall also be used.

### Connecting Attachment Plugs

1. Employees’ hands shall not be wet when plugging and unplugging flexible cords, cord- and plug-connected equipment if energized equipment is involved.
2. Energized plug and receptacle connections shall be handled only with insulating protective equipment if the condition of the connection could provide a conductive path to the employee’s hand (e.g. if a cord connector is wet from being immersed in water).
3. Locking-type connectors shall be secured after connection when present.

### Manufacturer’s Instructions

Portable equipment shall be used in accordance with the manufacturer’s instructions and safety warnings.

## Ground-Fault Circuit-Interrupter Protection

### General

Employees shall be provided with ground-fault circuit-interrupter (GFCI) protection where required by applicable state, federal, or local codes and standards. Listed cord sets or devices incorporating listed GFCI protection for personnel identified for portable use shall be permitted.

### Outdoors

GFCI protection shall be provided when an employee is outdoors and operating or using extension cords or cord- and plug-connected equipment supplied by 125-volt, 15-, 20-, or 30-ampere circuits. Where employees working outdoors operate or use equipment supplied by greater than 125-volt, 15-, 20-, or 30- ampere circuits, GFCI protection or an assured equipment grounding conductor program shall be implemented.

### Testing Ground-Fault Circuit-Interrupter Protection Devices

GFCI protection devices shall be tested in accordance with the manufacturer’s instructions.

## Overcurrent Protection Modification

Overcurrent protection of circuits and conductors shall not be modified, even on a temporary basis, beyond what is permitted by applicable portions of electrical codes and standards dealing with overcurrent protection. Any modifications made to overcurrent protection devices shall be documented and follow the work instruction [WI-051-EIC Overcurrent Protection Modifications](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/WI-051-EIC%20Overcurrent%20Protection%20Modifications.docx).

# Lockout and Electrically Safe Work Condition

## Lockout Program

### General

The lockout program specifies lockout procedures to safeguard workers from exposure to hazards and the supporting documentation requirements. The lockout program and procedures incorporates the following:

1. The experience and training of workers and conditions of the workplace
2. Meets the requirements of NFPA 70E Article 120 and OSHA 1910.147
3. Applies to fixed, permanently installed equipment, temporarily installed equipment and portable equipment

### Employer Responsibilities

Management is responsible for the following:

1. Providing the equipment necessary to execute the lockout procedures
2. Providing lockout training to workers exposed to an electrical hazard when the risk associated with that hazard is not reduced to safe levels by applicable electrical installation requirements
3. Auditing the lockout program in accordance with section 8.1.3 of this document
4. Auditing the execution of the lockout procedure in accordance with section 8.1.3 of this document

### Lockout Program and Procedure Audit

The lockout program and procedure shall be audited by a Qualified Electrical Worker at intervals not to exceed 1 year. The audit shall cover at least one lockout in progress. The audit shall be designed to identify and correct the deficiencies in the following:

1. The lockout program and procedures
2. The lockout training
3. Worker execution of the lockout procedure

The audits shall be documented and maintained by the Safety Steering Committee for a minimum period of 3 years.

## Lockout Principles

### General

Electrical conductors and circuit parts shall not be considered to be in an electrically safe work condition until all of the requirements of Section 8 of this document have been met.

Safe work practices applicable to the circuit voltage and energy level shall be used in accordance with Section 9 of this document until such time that electrical conductors and circuit parts are in an electrically safe work condition.

### Employee Involvement

Each person who could be exposed directly or indirectly to a source of electrical energy shall be involved in the lockout process. All exposed employees, non-employees and contractors are required to apply a physical lock in accordance with the lockout procedure.

**Informational Note:** Indirect exposure refers to an unaccepted risk of an electrical hazard when executing a work task even if the assignment is not electrical.

### Lockout Procedure

A lockout procedure shall be developed based on the existing electrical equipment and system hazards. Suitable documentation shall be used, including up-to-date drawings and diagrams.

### Control of Energy

All sources of electrical energy shall be controlled in such a way as to minimize employee exposure to electrical hazards. If other energy sources are present, including stored energy and mechanical energy, the sources must be removed or controlled through applicable means.

### Electrical Circuit Interlocks

Documentation, including up-to-date drawings and diagrams, shall be reviewed to ensure that no electrical circuit interlock operations can result in the reenergizing the circuit being worked on.

 **Informational Note:** Special care should be given to review documentation for the possibility of a circuit to be reenergized from backfeeds or operation of remote interlocks and control schemes.

### Control Devices

Locks shall be installed only on circuit disconnecting means. Control devices, such as push buttons or selector switches, shall not be used as the primary isolating device.

 **Informational Note:** OSHA 1910.147 requires lockout devices to be affixed to energy isolating devices. OSHA defines energy isolating devices as, “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 disconnect grounded supply conductors, and in addition, no pole can be operatively independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selector switchers, and other control circuit type devices are not energy isolating devices.”

### Identification

The lockout device shall be unique and readily identifiable as a lockout device.

### Coordination

The following items are necessary for coordinating the lockout procedure:

1. The electrical lockout procedure shall be coordinated with EIC work instructions, SOPs, and other facility procedures for control of exposure to electrical energy sources such that all EIC procedural requirements are adequately addressed.
2. The procedure for control of exposure to electrical hazards shall be coordinated with other procedures for control of other hazardous energy based on similar or identical concepts.
3. Electrical lockout devices shall be permitted to be similar to lockout devices for control of other hazardous energy sources, such as pneumatic, hydraulic, thermal and mechanical, if such devices are used only for control of hazardous energy and for no other purpose.

### Forms of Control of Hazardous Electrical Energy

Three forms of hazardous electrical energy control shall be permitted:

1. Simple Lockout where the qualified person shall be in charge of the lockout process. Form: F-053-EIC Electrical Safety Task Analysis
2. Complex Lockout where the person in charge shall have overall responsibility for the lockout process. Form: F-054-EIC Complex Lockout
3. Electrical Lab Project Assessment where the Student Qualified Electrical Worker or Qualified Electrical Worker shall be in charge of the lockout process. Form: F-052-EIC Electrical Lab Project Assessment

## Lockout Equipment

### Lock Application and Colors

#### Red Locks

Red locks are to be used for individual lockout at a device or on a group lockout box.

#### Blue Locks

Blue locks are to be used only for group boxes and group lockouts shall require a complex lockout form.

#### Gold Locks

Gold locks are utilized for securing devices or equipment where opening or operation of a device could contain a hazard but is not directly part of an active lockout. Gold locks shall not be used as part of the lockout program.

#### Green Locks

Green locks are utilized for securing devices or equipment where there are no additional hazards. Green locks shall not be used as part of the lockout program.

#### Purple Locks

Purple locks are used by the maintenance department to secure machinery. Purple locks are not a part of the lockout program.

### Lockout Devices

All lockout devices shall meet the following requirements:

1. A lockout device shall include a lock – either keyed or combination.
2. The lockout device shall include a method of identifying the individual who installed the lockout device.
3. A lockout device shall be permitted to be only a lock, if the lock is readily identifiable, as a lockout device, in addition to having a means of identifying the person who installed the lock.
4. Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.
5. Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.
6. Lockout devices shall be suitable for the environment and for the duration of the lockout.
7. Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

## Lockout Procedures

The employer shall maintain a copy of the procedures required by this section and shall make the procedures available to all employees.

### Planning

1. **Locating Sources** – up-to-date single-line drawings shall be considered a primary reference source for locating sources and shall be documented in the procedure. When up-to-date drawings are not available, the employer shall be responsible for ensuring and documenting that an equally effective means of locating all sources of energy is employed.
2. **Exposed Personnel** – All personnel with potential exposure to electrical hazards must identify required PPE in the procedure. All exposed employees, non-employees and contractors are required to apply a physical lock in accordance with the lockout procedure.
3. **Person in Charge** – the procedure shall identify the person in charge and his or her responsibility in the lockout
4. **Simple Lockout** – All lockout procedures that involve only a qualified person(s) de-energizing one set of conductors or circuit part source for the sole purpose of safeguarding employees from exposure to electrical hazards shall be considered to be a simple lockout procedure. Simple lockout procedures shall not be required to be written for each application. Each worker shall be responsible for his or her own lockout.
	1. Exception: Lockout is not required for work on cord- and plug-connected equipment for which exposure to the hazards is controlled by the unplugging of the equipment from the energy source, provided that the plug is under the exclusive control of the employee performing the servicing and maintenance for the duration of the work.
5. **Complex Lockout** –
	1. A complex lockout procedure shall be permitted where one or more of the following exists:
		1. Multiple energy sources
		2. Multiple crews
		3. Multiple crafts
		4. Multiple locations
		5. Multiple employers
		6. Multiple disconnecting means
		7. Particular sequences
		8. Job or task continues for more than one work period
	2. All complex lockout procedures shall require a written plan of execution that identifies the person in charge
	3. The complex lockout procedure shall vest primary responsibility in an authorized employee for employees working under the protection of a group lockout device, such as an operation lock or lockbox. The person in charge shall be held accountable for safe execution of the complex lockout procedure.
	4. Each authorized employee shall affix a personal lockout device to the group lockout device, group lockbox or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the device locked out.
	5. All complex lockout plans shall identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout.

### Elements of Control

1. **De-energized Equipment** – the procedure shall establish the person who performs the switching and where and how to de-energize the load.
2. **Stored Energy** – the procedure shall include requirements for releasing stored electric or mechanical energy that might endanger all personnel. All capacitors shall be discharged, and high capacitance elements shall also be short-circuited and grounded before the associated equipment is touched or worked on. Springs shall be released or physical restraint shall be applied when necessary to immobilize mechanical equipment and pneumatic and hydraulic pressure reservoirs. Other sources of stored energy shall be blocked or otherwise relieved.
3. **Disconnecting Means** – the procedure shall identify how to verify that the circuit is de-energized (open circuit).
4. **Responsibility** – the procedure shall identify the person who is responsible for verifying that the lockout procedure is implemented and who is responsible for ensuring that the task is completed prior to removing locks. A mechanism to accomplish lockout for multiple (complex) jobs/tasks where required, including the person responsible for coordination, shall be included.
5. **Verification** – the procedure shall verify that equipment cannot be restarted. The equipment operating controls, such as push-buttons, selector switches, and electrical interlocks, shall be operated or otherwise it shall be verified that the equipment cannot be restarted.
6. **Testing** – the procedure shall establish the following:
	1. Test instruments to be used, the required PPE and the person who will use it to verify proper operation of the test instrument on a known voltage source before and after use
	2. Requirement to define the boundary of the electrically safe work condition
	3. Requirement to test before touching every exposed conductor or circuit part(s) within the defined boundary of the work area
	4. Requirement to retest for absence of voltage when circuit conditions change or when the job location has been left unattended
7. **Grounding** – if required for the application, grounding for the circuit shall be established, including whether the temporary protective grounding equipment shall be installed for the duration of the task or is temporarily established by the procedure. Grounding needs or requirements shall be permitted to be covered in other work rules and might not be part of the lockout procedure.
8. **Shift/Team Change** – a method shall be identified in the procedure to transfer responsibility for lockout to another person or to the person in charge when the job or task extends beyond the established shift/team.
9. **Coordination** – The procedure shall establish how coordination is accomplished with other jobs or tasks in progress, including related jobs or tasks at remote locations as well as the person responsible for coordination.
10. **Accountability for Personnel** – A method shall be identified in the procedure to account for all persons who could be exposed to hazardous energy during the lockout.
11. **Lockout Application** – The procedure shall clearly identify when and where lockout applies and shall address the following:
	1. Lockout shall be defined as installing a lockout device on all sources of hazardous energy such that operation of the disconnecting means is prohibited and forcible removal of the lock is required to operate the disconnecting means.
	2. Where it is not possible to attach a lock to existing disconnecting means, the disconnecting means shall not be used as the only means to put the circuit in an electrically safe work condition.
12. **Removal of Lockout** – If the installing individual is unavailable, an attempt shall be made to contact the individual. The lock maybe removed using the Form: [F-063-EIC Lock Removal](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/F-063-EIC%20Lock%20Removal.docx). When the lock is removed because the installer is unavailable, the installer shall be informed prior to returning to work.
13. **Release for Return to Service** – The procedure shall identify steps to be taken when the job or task requiring lockout is completed. Before electric circuits or equipment are re-energized, tests and visual inspections shall be conducted to verify that all tools, mechanical restraints and electrical jumpers, short circuits, and temporary protective grounding equipment have been removed, so that the circuits and equipment are in a condition to be safely energized. When applicable, the employees responsible for operating the machines or processes shall be notified when circuits and equipment are ready to be energized, and such employees shall provide assistance as necessary to safely energize the circuits and equipment. The procedure shall contain a statement requiring the area to be inspected to ensure that nonessential items have been removed. One such step shall ensure that all personnel are clear of exposure to dangerous conditions resulting from reenergizing the service and that blocked mechanical equipment or grounded equipment is cleared and prepared for return to service.
14. **Temporary Release for Testing/Positioning** – The procedure shall clearly identify the steps and qualified persons’ responsibilities when the job or task requiring lockout is to be interrupted temporarily for testing or positioning of the equipment; then the steps shall be identical to the steps for return to service.

## Process for Establishing and Verifying an Electrically Safe Work Condition

Establishing and verifying an electrically safe work condition shall include all of the following steps, which shall be performed in the order presented if feasible:

1. Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams and identification tags.
2. After properly interrupting the load current, open the disconnecting device(s) for each source.
3. Wherever possible, visually verify that all blades of the disconnect devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position.
4. Release stored electrical energy.
5. Release or block stored mechanical energy.
6. Apply lockout devices in accordance with a documented and established procedure.
7. Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any know voltage source.
	1. Exception 1 – Adequately rated permanently mounted test device is permitted if all of the following conditions are met:
		1. It is permanently mounted and installed in accordance with the manufacturer's instructions and test the conductors and circuit part at the point of work.
		2. It tests each phase for the purpose of verifying the absence of voltage.
		3. It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground.
		4. The test device is verified as operating satisfactory on any known voltage source before and after verifying the absence of voltage.
	2. Exception 2 – on electrical systems over 1000 volts, noncontact test instruments shall be permitted to be used to test each phase conductor.
8. Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:
	1. Placement – temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard.
	2. Capacity – temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.
	3. Impedance – temporary protective grounding equipment and conductors shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

# Work Involving Electrical Hazards

This section is intended to implement NFPA 70E Article 130.

## General

This section of the Electrical Safety Program covers the following:

1. When an electrically safe work condition must be established.
2. Requirements for work involving electrical hazards such as the electrical safety-related work practices, assessments and precautions, and procedures when electrically safe work condition cannot be established.

## Performing Electrical Work

Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:

1. The employee is within the limited approach boundary of an exposed conductor.
2. The employee interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

Equipment that meets the requirements of UL 508A are not considered exposed conductors. (Engineered controls such as recessed electrodes, etc.)

### Energized Work

Energized work is working on or near energized conductors or circuit parts. Energized work includes intentionally coming in contact with energized electrical conductors or circuit parts with hands, feet, or other body parts, with tools, probes, or with any test equipment, regardless of the PPE a person is wearing. Energized work is separated into two categories:

1. Diagnostic (testing) is taking reading or measurements of electrical equipment with approved test equipment that does not require making any physical changes to the equipment.
2. Physical alteration of equipment or repair (such as making or tightening connections, removing or replacing components, moving or stressing conductors while energized, etc.).

### Energized Work Justifications:

1. **Additional Hazards or Increased Risk** – Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk.
2. **Infeasibility** – Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.
3. **Equipment Operating at Less Than 50 Volts** – Energized electrical conductors and circuit parts that operate at less than 50 volts shall not be required to be de-energized where the capacity of the source and any overcurrent protection between the energy source and the worker are considered and it is determined that there will be no increased exposure to electrical burns or to explosions due to electrical arcs.
4. **Normal Operating Conditions** – Normal operating of electric equipment shall be permitted where a normal operating condition exists. A normal operating condition exists when all of the following conditions are satisfied:
	1. The equipment is properly installed
	2. The equipment is properly maintained
	3. The equipment is used in accordance with instructions included in the listing and labeling and in accordance with the manufacturer’s instructions
	4. The equipment doors are closed and secured
	5. All equipment covers are in place and secured
	6. There is no evidence of impending failure
5. **Battery System** – Prior to any work on a battery system, a risk assessment shall be performed to identify the chemical, electrical shock, arc flash hazards and any risk associated with the type of tasks to be performed. Using the results of the risk assessment procedure and the hierarchy of risk control methods, the energy threshold for battery systems may be raised or lowered based on the risk assessment.

### Energized Electrical Work Permit

The Energized Electrical Work Permit is form [F-055 Energized Work Permit](https://clemson.sharepoint.com/teams/SafetySteeringCommitee/Shared%20Documents/Safety%20System%20Documents/Safety%20Policies%20and%20Programs/F-055%20Energized%20Work%20Permit.docx).

1. **When Required** – when work is performed as permitted in section 9.2.1, an energized work permit shall be required and documented under the following conditions.
	1. When work is performed within the restricted approach boundary.
	2. When the employee interacts with the equipment when conductors for circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.
2. **Exemptions to Energized Work Permit** – Electrical work shall be permitted without an energized work permit if a qualified person is provided with and uses the appropriate safe work practices and PPE in accordance with this document under any of the following conditions:
	1. Testing, troubleshooting, or voltage measuring.
	2. Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed.
	3. Access to and egress from the area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed.
	4. General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed.
	5. Operations and tasks covered under approved standard operating procedures, work instructions, or F-052-EIC Electrical Lab Project Assessment Form, which meet the requirements of NFPA 70 Article 130.2, Elements of Work Permit.

## Working While Exposed to Electrical Hazards

Safety related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazards and the associated risk.

Appropriate safety-related work practices shall be determined before any person is exposed to the electrical hazards involved by using both shock risk assessment and arc flash risk assessment. Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.

## Shock Risk Assessment

### General

A shock risk assessment shall be performed and documented in the ESTA:

1. To identify shock hazards
2. To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health
3. To determine if additional protective measures are required, including the use of PPE

### Additional Protective Measures

If additional protective measures are required, follow the hierarchy of controls. When the additional protective measures include the use of PPE, the following shall be determined:

1. The voltage to which personnel will be exposed
2. The shock boundary requirements – limited and restricted approach boundaries
3. The personal and other protective equipment required to protect against the shock hazard

### Documentation

The ESTA shall document the results of the risk assessment described above in 9.4.1 and 9.4.2.

### Shock Protection Boundaries

The shock protection boundaries identified as limited approach boundary and restricted approach boundary shall be applicable where personnel are approaching exposed energized electrical conductors or circuit parts. Shock protection boundaries for AC and DC systems shall be in accordance with NFPA 70E. Equipment labeling may include shock boundaries and shall comply with NFPA 70E.

### Limited Approach Boundary

1. **Unqualified Person Entering the Limited Approach Boundary** – No unqualified person shall be permitted to approach nearer than the limited approach boundary of energized conductors and circuit parts unless absolutely deemed necessary. Where there is a need for unqualified person(s) to cross the limited approach boundary, a qualified person shall advise the unqualified person(s) of the possible hazards and continuously escort the unqualified person(s) while inside the limited approach boundary. Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.
2. **Working at or Close to the Limited Approach Boundary** – Where one or more unqualified persons are working at or close to the limited approach boundary, the designated person in charge for the work space where the electrical hazard exists shall advise the unqualified person(s) of the electrical hazard and warn him or her to stay outside of the limited approach boundary.

### Restricted Approach Boundary

No qualified person shall approach or take any conductive object closer to exposed energized conductors or circuit parts than the restricted approach boundary specified in NFPA 70E, unless one of the following conditions applies:

1. The qualified person is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is performed.
2. The energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.

## Arc Flash Risk Assessment

### General

An arc flash risk assessment shall be performed and documented in the ESTA:

1. To identify arc flash hazards
2. To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health
3. To determine if additional protective measures are required, including the use of PPE

### Estimate of Likelihood and Severity

The estimate of the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health shall take into consideration the following:

1. The design of the electrical equipment, including its overcurrent protective device and its operating time
2. The electrical equipment operating condition and condition of maintenance

### Additional Protective Measures

If additional protective measures are required, follow the hierarchy of controls. When the additional protective measures include the use of PPE, the following shall be determined:

1. Appropriate safety-related work practices
2. The arc flash boundary
3. The PPE to be used within the arc flash boundary

### Documentation

The ESTA shall document the results of the risk assessment described above in 9.5.1, 9.5.2, and 9.5.3.

### Arc Flash Boundary

The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm^2. In absence of an arc flash calculation performed at a particular location, then the table method outlined in NFPA 70E may be used as long as all conditions of the table are met. The table method shall never supersede a calculated arc flash boundary.

### Arc Flash PPE

The incident energy analysis method shall be used for the selection of arc flash PPE in accordance with NFPA 70E 130.5. In absence of an arc flash calculation performed at a particular location, then the table method outlined in NFPA 70E may be used as long as all conditions of the table are met. The table method shall never supersede a calculated incident energy for selection of arc flash PPE.

The table below indicates a simplified approach for the minimum requirements for arc flash PPE that the EIC will make available and maintain for employees exposed to arc flash hazards. Under this program, any combination of arc flash PPE that is in compliance with NFPA 70E and federal, state and local codes may be used.

**Table of EIC Available Arc Flash PPE**

|  |  |  |
| --- | --- | --- |
| **Incident Energy Method** | **Category Method** | **Required Clothing and PPE** |
| Exposure less than 1.2 cal/cm2 | N/A | Non-melting or natural fiber shirt, pants, or overall. Safety Glasses  |
| Exposure equal to 1.2 cal/cm2 up to 12 cal/cm2 | Category 1&2 | **Arc Clothing:**12cal/cm2 arc-rated overall and jacket. 12cal/cm2 arc-rated hoodHard HatHeavy Duty Leather Gloves or rubber insulating gloves with leather protectors.Safety Glasses or Safety googlesHearing ProtectionLeather footwearArc Rated fall-protection (as required) |
| Greater than 12 cal/cm2 up to 40 cal/cm2 | Category 3&4 | **Arc Clothing:**40cal/cm2 arc-rated overall and jacket. 40cal/cm2 arc-rated hoodHard HatRubber insulating gloves with leather protectors Safety Glasses or Safety googlesHearing ProtectionLeather footwearArc Rated fall-protection (as required) |
| Equal to 40cal/cm2 and above | N/A | Energized work by EIC employees on systems equal to or greater than 40cal/cm2 is strictly prohibited. Every precaution and control should be taken to reduce the incident energy to less than 40cal/cm2 or using different system test points with a lower incident energy for ESWC. If the arc flash risk cannot be lowered or mitigated, the SSC shall review task, procure the necessary PPE defined by the NFPA 70E listed in section 5, and ensure the workers are appropriately trained on the task and risk.  |

### Incident Energy Analysis Method

The methods described in IEEE Std. 1584 shall be used for analysis of the incident energy.

### Arc Flash PPE Category Method

The Arc Flash PPE Category Method in NFPA 70E may be used if a piece of equipment does not have a posted incident energy and the task urgency does not permit the adequate time and resources to complete an incident energy analysis.

### Equipment Labeling

Electrical equipment such as switchboards, panel boards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing or maintenance while energized shall be marked with a label containing all of the following information:

1. Nominal system voltage
2. Arc flash boundary
3. Available incident energy and the corresponding working distance or the arc flash PPE category

Labeling may include shock boundary values and shall comply with respective NFPA 70E values.

## Other Precautions for Personnel Activities

### Alertness

#### When Electrical Hazards Might Exist

Employees shall be alert at all times when they are working within the limited approach boundary of energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts and in work situations when electrical hazards might exist.

#### When Impaired

Employees shall not work within the limited approach boundary of energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts, or where other electrical hazards exist, while their alertness is recognizably impaired due to illness, fatigue, or other reasons.

#### Changes in Scope

Employees shall be alert for changes in the job or task that could lead the person outside of the electrically safe work condition or expose the person to additional hazards that were not part of the original plan.

### Blind Reaching

Employees shall not reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

### Illumination

#### General

Employees shall not enter spaces where electrical hazards exist unless illumination is provided that enables the employees to perform the work safely.

#### Obstructed View of Work Area

Where lack of illumination or an obstruction precludes observation of work to be performed, employees shall not perform any task within the limited approach boundary of energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists.

### Conductive Articles Being Worn

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 within the restricted approach boundary or where they present an electrical hazard with exposed energized electrical conductors or circuit parts.

### Conductive Materials, Tools, and Equipment Being Handled

#### General

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 unintentional contact with energized electrical conductors or circuit parts. Such materials and equipment shall include, but are not limited to, long conductive objects, such as ducts, pipes, and tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, bull floats, and chains.

#### Approach to Energized Electrical Conductors and Circuit Parts

Means shall be employed to ensure that conductive materials approach exposed energized electrical conductors or circuit parts no closer than permitted shock hazard approach boundaries specified by NFPA 70E 130.2.

### Confined or Enclosed Work Spaces

When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts and the effects of the electrical hazards.

### Doors and Hinged Panels

Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard.

### Clear Spaces

Working space required by codes and standards shall not be used for storage. This space shall be kept clear to permit safe operating and maintenance of electrical equipment.

### Housekeeping Duties

Employees shall not perform housekeeping duties inside the limited approach boundary where there is a possibility of contact with energized electrical conductors or circuit parts, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions) shall not be used inside the limited approach boundary unless procedures to prevent electrical contact are followed.

### Occasional Use of Flammable Materials

Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be permitted to be used, unless measures are taken to prevent hazardous conditions from developing. Such materials include, but are not limited to, flammable gases, vapors, or liquids, combustible dust or ignitable fibers or filings.

### Anticipating Failure

When there is evidence that electric equipment could fail and injure employees, the electric equipment shall be de-energized. Until the equipment is de-energized or repaired, employees shall be protected from hazards associated with the impending failure of the equipment by suitable barricades and other alerting techniques necessary for safety of the employees.

### Routine Opening and Closing of Circuits

Load-rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors of the load-break type, fuses, terminal lugs, and cable splice connections shall not be permitted to be used for such purposes, except in an emergency.

### Reclosing Circuits After Protective Device Operation

After a circuit is de-energized by the automatic operation of a circuit protective device, the circuit shall not be manually re-energized until it has been determined that the equipment and circuit can be safely energized. The repetitive manual reclosing of circuit breakers or re-energizing circuits through replaced fuses shall be prohibited. When it is determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, examination of the circuit or connected equipment shall not be required before the circuit is re-energized.

### Safety Interlocks

Only qualified persons following the requirements for working inside the restricted approach boundary as covered by NFPA 70E 130.4(D) shall be permitted to defeat or bypass an electrical safety interlock over which the person has sole control, and then only temporary while the qualified person is working on the equipment. The safety interlock system shall be returned to its operable condition when the work is completed.

### Cutting or Drilling

Before cutting or drilling into equipment, floors, walls or structural elements where a likelihood of contacting energized electrical lines or parts exist, the employer shall perform a Safety Task Analysis.

## Personal and Other Protective Equipment

### General

Employees exposed to electrical hazards that have not been adequately reduced by the applicable electrical installation requirements, shall be provided with, and shall use, protective equipment that is adequate to control the exposure or hazard for all exposed parts of the body.

### Care of Equipment

Protective equipment shall be maintained in a safe, clean, and reliable condition and in accordance with manufacturers’ instructions. The protective equipment shall be visually inspected before each use. Protective equipment shall be stored in a manner to prevent damage from physically damaging conditions and from moisture, dust, or other deteriorating agents.

### Rubber Insulating Equipment Maximum Test Intervals

The following rubber insulating will comply with required regulatory testing.

|  |  |
| --- | --- |
| Rubber Insulating Equipment | When to test |
| Blankets | Before first issue; every 12 months thereafter\* |
| Covers | If insulating value is suspect |
| Gloves | Before first issue; Every 6 months thereafter\* |
| Line Hose | If insulating value is suspect |
| Sleeves | Before first issue; Every 12 months thereafter\* |

\*New insulating equipment is not permitted to be placed into service unless it has been electrically tested within the previous 12 months. Insulating equipment that has been issued for service is not new and is required to be retested in accordance with the intervals in the table above.

### Personal and Other Protective Equipment (PPE)

This Electrical Safety Program includes by reference the Personal and Other Protective Equipment requirements as outlined in NFPA 70E 130.7, including:

1. General
2. Movement and Visibility
3. Head, Face, Neck, and Chin (Head Area) Protection
4. Eye Protection
5. Hearing Protection
6. Body Protection
7. Head and Arm Protection
8. Foot Protection
9. Factors in Selection of Protective Clothing and Fall Protection (Outer Layer)
10. Arc Flash Protective Equipment
11. Clothing Material Characteristics
12. Clothing and Other Apparel Not Permitted
13. Care and Maintenance of Arc-Rated Clothing and Arc Rated Arc Flash Suits
14. Standards for Personal Protective Equipment
15. Arc Flash PPE Category Method

### Other Protective Equipment

#### Insulated Tools and Equipment

Employees shall use insulated tools or handling equipment, or both, when working inside the restricted approach boundary of exposed energized electrical conductors or circuit parts where tools or handling equipment might make unintentional contact. Insulated tools shall be protected from damage to the insulating material.

This Electrical Safety Program includes by reference the requirements NFPA 70E 130.7(D)(1) for specific tools, ladders, protective shields, rubber insulating equipment, voltage-rated plastic guard equipment, physical or mechanical barriers, etc.

### Alerting Techniques

#### Safety Signs and Tags

Safety signs, safety symbols, or tags shall be used where necessary to warn employees about electrical hazards that might endanger them. Such signs and tags shall meet the requirements of applicable state, federal, or local codes and standards.

#### Barricades

Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas containing energized conductors or circuit parts. Conductive barricades shall not be used where it might increase the likelihood of exposure to an electrical hazard.

Barricades shall be placed no closer than the limited approach boundary given in Table 130.4(D)(a) and Table 130.4(D)(b). Where the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary. Where a barricade is used to maintain an arc flash boundary, limited approach boundary, or unattended electrical hazards, the color shall be red.

#### Attendants

If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees. The primary duty and responsibility of this attendant shall be to provide manual signaling and alerting to keep unqualified employees outside a work area where the unqualified employee might be exposed to electrical hazards. An attendant shall remain in the area as long as there is a potential for employees to be exposed to the electrical hazards.

#### Cutting, Removing, or Rerouting of Conductors

Where conductors are de-energized in order to cut, remove, or reroute them and conductor terminations are not within sight, such as where they are in a junction or pull box, additional steps to verify the absence of voltage or identify the conductors shall be taken prior to cutting, removing, or rerouting the conductors.

### Look-Alike Equipment

Where the work performed on equipment that is de-energized and placed into an electrically safe condition exists in a work area with other energized equipment that is similar in size, shape, and construction, one of the alerting methods in 9.7.5 shall be employed to prevent the employee from entering look-alike equipment.

### Standards for Other Protective Equipment

All protective equipment shall meet federal, state and local codes and standards where applicable.

# Safety-Related Maintenance Requirements

## General Maintenance Requirements

### Qualified Persons

The person in charge of maintenance on electrical equipment and installations shall be a qualified electrical worker and shall be trained in, and familiar with, the specific maintenance procedures and tests required.

### Single-Line Diagram

A single-line diagram, where provided for the electrical system, shall be maintained in a legible condition and shall be kept current.

### General Maintenance Requirements

Electrical equipment shall be maintained in accordance with manufacturers’ instructions or industry consensus standards to reduce the risk associated with failure. The equipment owner or the owner’s designated representative shall be responsible for maintenance of the electrical equipment and documentation.

### Overcurrent Protective Devices

Overcurrent protective devices shall be maintained in accordance with the manufacturers’ instructions or industry consensus standards. Maintenance, tests, and inspections shall be documented.

### Spaced About Electrical Equipment

All working space and clearances required by electrical codes and standards shall be maintained.

### Grounding and Bonding

Equipment, raceway, cable tray, and enclosure bonding and grounding shall be maintained to ensure electrical continuity.

### Guarding of Energized Conductors and Circuit Parts

Enclosures shall be maintained to guard against unintentional contact with exposed energized conductors and circuit parts and other electrical hazards. Covers and doors shall be in place with all associated fasteners and latches secured.

### Safety Equipment

Locks, interlocks, and other safety equipment shall be maintained in proper working condition to accomplish the control purpose.

### Clear Spaces

Access to working space and escape passages shall be kept clear and unobstructed.

### Identification of Components

Identification of components, where required, and safety-related instructions (operating or maintenance), if posted, shall be securely attached and maintained in legible condition.

### Warning Signs

Warning signs, where required, shall be visible, securely attached, and maintained in legible condition.

### Identification of Circuits

Circuits or voltage identification shall be securely affixed and maintained in updated and legible condition.

### Single and Multiple Conductors and Cables

Electrical cables and single and multiple conductors shall be maintained free of damage, shorts, ground that would expose employees to an electrical hazard.

### Flexible Cords and Cables

Flexible cords and cables shall be maintained to preserve insulation integrity.

Cords and cables shall not have worn, frayed, or damaged areas that would expose employees to an electrical hazard.

Strain relief of cords and cables shall be maintained to prevent pull from being transmitted directly to joints or terminals.

Cords and cord caps for portable electrical equipment shall be repaired and replaced by qualified personnel and checked for proper polarity, grounding, and continuity prior to returning to service.

## Substations, Switchgear Assemblies, Switchboards, Panelboards, Motor Control Centers, and Disconnect Switches

### Enclosures

Enclosures shall be kept free of material that would expose employees to an electrical hazard.

### Area Enclosures

Fences, physical protection, enclosures, or other protective means, where required to guard against unauthorized access or unintentional contact with exposed energized conductors and circuit parts, shall be maintained.

### Conductors

Current-carrying conductors (buses, switches, disconnects, joints, and terminations) and bracing shall be maintained to (1) conduct rated current without overheating and (2) withstand available fault current.

### Insulation Integrity

Insulation integrity shall be maintained to support the voltage impressed.

### Protective Devices

Protective devices shall be maintained to adequately withstand or interrupt available fault current.

## Premises Wiring

### Covers for Wiring System Components

Covers for all wiring system components shall be in place with all associated hardware, and there shall be no unprotected openings.

### Open Wiring Protection

Open wiring protection, such as location or barriers, shall be maintained to prevent unintentional contacts.

### Raceways and Cable Trays

Raceways and cable trays shall be maintained to provide physical protection and support for conductors.

## Controller Equipment

### Scope

This article shall apply to controllers, including electrical equipment that governs the starting, stopping, direction of motion, acceleration, speed, and protection of rotating equipment and other power utilization apparatus in the workplace.

### Protection and Control Circuitry

Protection and control circuitry used to guard against unintentional contact with exposed energized conductors and circuit parts and to prevent other electrical or mechanical hazards shall be maintained.

## Fuses and Circuit Breakers

### Fuses

Fuses shall be maintained free of breaks or cracks in fuse cases, ferrules, and insulators. Fuse clips shall be maintained to provide adequate contact with fuses. Fuseholders for current-limiting fuses shall not be modified to allow the insertion of fuses that are not current-limiting. Non-current limiting fuses shall not be modified to allow their insertion into current-limiting fuseholders.

### Molded-Case Circuit Breakers

Molded-case circuit breakers shall be maintained free of cracks in cases and cracked or broken operating handles.

### Circuit Breaker Testing After Electrical Faults

Circuit breakers having interrupted faults approaching their interrupting ratings shall be inspected and tested in accordance with the manufacturer’s instructions.

## Rotating Equipment

### Terminal Boxes

Terminal chambers, enclosures, and terminal boxes shall be maintained to guard against unintentional contact with exposed energized conductors and circuit parts and other electrical hazards.

### Guards, Barriers, and Access Plates

Guards, barriers, and access plates shall be maintained to prevent employees from contacting or moving energized parts.

## Hazardous (Classified) Locations

The EIC does not have any hazardous (classified) locations.

## Batteries and Battery Rooms

### Ventilation

When forced or natural ventilation systems are required by the battery system design and are present, they shall be examined and maintained to prevent buildup of explosive mixtures. This maintenance shall include a functional test of any associated detection and alarm systems.

### Eye and Body Wash Apparatus

Eye and body wash apparatus shall be maintained in operable conditions.

## Portable Electric Tools and Equipment

### Maintenance Requirements for Portable Electric Tools and Equipment

Attachment plugs, receptacles, cover plates, and cord connectors shall be maintained such that the following criteria are met:

1. There are no breaks, damage, or cracks exposing energized conductors and circuit parts.
2. There are no missing cover plates.
3. Terminations have no stray strands or loose terminals.
4. There are no missing, loose, altered, or damaged blades, pins, or contacts.
5. Polarity is correct.

## Personal Safety and Protective Equipment

### Maintenance Requirements for Personal Safety and Protective Equipment

Personal safety and protective equipment such as the following shall be maintained in safe working condition:

1. Grounding equipment
2. Hot sticks
3. Rubber gloves, sleeves, and leather protectors
4. Test instruments
5. Blanket and similar insulating equipment
6. Insulating mats and similar insulating equipment
7. Protective barriers
8. External circuit breaker rack-out devices
9. Portable lighting units
10. Temporary protective grounding equipment
11. Dielectric footwear
12. Protective clothing
13. Bypass jumpers
14. Insulated and insulating hand tools

### Inspection and Testing of Protective Equipment and Protective Tools

#### Visual Inspection

Safety and protective equipment and protective tools shall be visually inspected for damage and defects before initial use and at intervals thereafter, as service conditions require, but in no case shall the interval exceed 1 year.

#### Testing

The insulation of protective equipment and protective tools, such as items specified in 10.10.1, that is used as primary protection from shock hazards and requires an insulation system to ensure protection of personnel shall be verified by the appropriate test and visual inspection to ascertain that insulating capability has been retained before initial use, and at intervals thereafter, as service conditions and applicable standards and instructions require, but in no case shall the interval exceed 3 years.

### Safety Grounding Equipment

#### Visual Inspection

Personal protective ground cable sets shall be inspected for cuts in the protective sheath and damage to the conductors. Clamps and connector strain relief devices shall be checked for tightness. These inspections shall be made at intervals thereafter as service conditions require, but in no case shall the interval exceed 1 year.

#### Testing

Prior to being returned to service, temporary protective grounding equipment that has been repaired or modified shall be tested.

### Grounding and Testing Devices

Grounding and testing devices shall be stored in a clean and dry area. Grounding and testing devices shall be properly inspected and tested before each use.

### Test Instruments

Test instruments and associated test leads used to verify the absence or presence of voltage shall be maintained to assure functional integrity.

# Safety Requirements for Special Equipment

The Safety Steering Committee will serve as the Electrical Safety Authority for the purposes of NFPA 70E Article 300 and will assign designated QEW(s) for all laboratory projects. This QEW will serve as the designated subject matter expert. The designated subject matter expert will utilize NFPA Article 350 as a guideline for any exceptions or modifications to procedures established in this SOP.

This person is required to:

1. Understand the purpose of the electrical test equipment
2. Construction and operation of the equipment
3. Read the manufacturer documentation
4. Consult with the manufacturer for any modifications to equipment
5. Establish the lockout procedures

# Revision History

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| --- | --- | --- | --- | --- |
| Revision | Date | Summary of change | Author | Approver |
| A | 10/22/2020 | Initial issue | J. Curtiss FoxJesse LeonardNancy LaFlairThomas SalemRandy Collins | Kurt RayburgRandy CollinsJ. Curtiss FoxTom SalemJesse LeonardJim TutenKonstantin Bulgakov |
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