

CHAPTER 16 – ELECTRICAL SAFETY

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ATTACHMENTS

APPENDIX 1 - SPECIFIC WORK-RELATED ELECTRICAL SAFETY FOR ELECTRICAL QUALIFIED PERSONS (Mandatory)

A. INTRODUCTION

Electricity has become an essential of modern life, both at home and on the job. Some employees work with electricity directly, as is the case with engineers, electricians or people who work with wiring, such as overhead lines, cable harnesses, exhibits lighting or circuit assemblies. Others, such as sales people, office, custodial and warehouse personnel, work with it indirectly, such as the use of electrical powered equipment including copiers, shredders, vacuum cleaners, and kitchen type appliances. As a source of power, electricity is accepted without much thought to the hazards associated with the use of electricity. Perhaps because electricity has become such a familiar part of our surroundings, it often is not treated with the respect it deserves.

B. PURPOSE

All employees working on and around electrical components are covered by this chapter, and shall be properly informed and trained in the procedures of the SI electrical safety program. This chapter is applicable to SI facilities, exhibits, maintenance, security, construction services, telecommunications, volunteers, interns, contractors, and visiting personnel who will conduct work activities. This chapter is not all inclusive of electrical safety- work practices and 29 CFR 1910.331-335 and NFPA 70E, Standard for Electrical Safety in the Workplace, shall be referred to for additional requirements. Specific applications shall be incorporated into Job Hazard Analysis (JHA), Standard Operating Procedures (SOP), and employee training for job tasks related to their work activities

This chapter and its procedures are intended to establish and implement a written comprehensive electrical safety program to prevent electric shock or other injuries resulting from direct/indirect electrical contact to employees working on or near energized or de-energized parts. This procedure applies to all work operations at the Smithsonian Institution (SI) where employees may be exposed to energized electrical conductors and circuit parts and/or those parts that have been de-energized.

C. DEFINITIONS

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

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

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

Arc Flash Protection Boundary – Where an arc flash hazard exists, and approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur.

Arc Flash Suit – A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet. An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating – The value attributed to materials that describe their performance to exposure to an electrical arc discharge.

Attachment Plug (plug). A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Authority Having Jurisdiction (AHJ) – An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. The Office of Safety, Health, and Environmental Management will act as the AHJ within SI per SD 419.

Circuit Breaker – A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Critical Systems – Those systems that would result in increased or additional hazards if de-energized (e.g. emergency alarm systems, hazardous locations ventilation equipment, area lighting)

Daisy Chaining – connecting two or more extension cords or relocatable power taps in series (i.e., one power strip plugged into another power strip).

De-energized – Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential difference from that of the earth.

Disconnecting Means - A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Electric Arc - An electrical arc is an electrical breakdown of a gas (e.g. air) which produces an ongoing plasma discharge, resulting from a current flowing through normally nonconductive media such as air. A synonym is arc discharge.

Electrical Hazard – A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn or blast.

Electrical Safety – Recognizing hazards associated with the use of electrical energy and taking precautions so that hazards do not cause injury or death.

Energized - Electrically connected to or is, a source of voltage.

Extension Cord- A flexible electrical power cord with a plug on one end and one or more sockets on the other end that has been approved by a Nationally Recognized Testing Laboratory (NRTL) i.e., UL, NTS, CSA, CCL, WL etc.

Ground - Connected to earth or to some conducting body that serves in place of the earth.

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

Ground Fault Circuit Interrupter (GFCI) – A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a device.

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 centimeter squared.

Incident Energy Analysis – A component of an arc flash hazard analysis used to predict the incident energy of an arc flash for a specified set of conditions.

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

Job Hazard Analysis (JHA) - A risk assessment of a specific job task or process whereby each segment of the job is examined to identify hazards so that preventive measures can be implemented to eliminate or reduce the hazards.

Limited Approach Boundary – An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

Lockout/Tagout – A procedure where equipment of machinery systems have had (1) all potential energy sources isolated (i.e. turned off); (2) all potential energy sources secured from reactivation (e.g. locked out); (3) all residual energy relieved from the system; and (4) all system controls activate, with safety verified. See Chapter 12, “Lockout/Tagout Program” of this manual for more details.

On-The-Job-Training (OJT) - An employee undergoing on-the-job training who has demonstrated the ability to perform duties safely at his or her level of training, and who is under the direct supervision of a qualified person, is considered to be a qualified person for the purpose of those duties.

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

Prohibited Approach Boundary - An approach limit at a distance from an exposed energized electrical conductor or circuit part within which work is considered the same as making contact with the electrical conductor or circuit part.

Qualified Persons – are those who have skills and knowledge related to the construction and operation of the electrical equipment and installations and have received safety training to recognize and avoid the hazards involved. Note: Qualified persons must be trained to the specific equipment involved in their duties since it is possible that a person may be considered qualified for certain equipment but not other equipment.

Receptacle – A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

Relocatable Power Taps commonly called (Power Strips) - A relocatable multiple outlet extension plugged directly into a wall receptacle that has been approved by a Nationally Recognized Testing Laboratory (NRTL) i.e., UL, NTS, CSA, CCL, WL etc.

Restricted Approach Boundary. An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased risk of shock, due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit part.

Shock Hazard – A dangerous condition associated with the possible release of energy caused by contact or approach to energized electrical conductors or circuit parts.

Unqualified Persons – a person who is not qualified , such as general office workers and others whose job tasks do not involve maintenance of electrical equipment.

Working On (live parts, *energized electrical conductors or circuit parts*) – The act of coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing. There are two categories of “working on”; diagnostic (testing) is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; repair is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.).

D. CHAPTER SPECIFIC ROLES AND RESPONSIBILITIES

1. Building Managers

- a. Ensure the provisions of the Electrical Safety Program are implemented and enforced.
- b. Ensure electrical safe work practices in Appendix 1 are implemented and followed by designated qualified persons when conducting electrical work activities.
- c. Ensure work areas are free from recognized electrical hazards, individuals working on electrical equipment and systems are authorized for such work, and an electrical safety program is implemented which includes management authorization, training, safe work practices, personal protective equipment and hazard recognition.
- d. Review and sign **Appendix 1, Attachment 1 Energized Electrical Work Permit** only after determination is made that an electrical safe work condition cannot be established due to reasons of increased or additional hazards or infeasibility due to equipment design or operational limitations. See Appendix 1, Section A .2, Working on Energized Parts.
- e. Maintain completed copies of Energized Electrical Work Permits.

2. Safety Coordinators

- a. Advise building managers and supervisors of the provisions of the Electrical Safety Program, to include electric safe work practices in Appendix 1, so the program can be properly implemented and enforced.

- b. Ensure SI staff receives required electrical safety training pursuant to the degree of hazards exposed.
- c. Assist supervisors in identifying and controlling electrical hazards as needed.
- d. Review and sign **Appendix 1, Attachment 1 Energized Electrical Work Permit** only after a determination is made that an electrical safe work condition cannot be established due to reasons of increased or additional hazards or infeasibility due to equipment design or operational limitations. Coordinate with Building Manager and supervisor as part of the determination. See Appendix 1 Section A.2., Working on Energized Parts, before work is performed on energized parts.

3. Supervisors

- a. Enforce the provisions of the Electrical Safety Program in your area of responsibility.
- b. Ensure that all employees are thoroughly aware of their electrical safety responsibilities and that safety practices are followed at all times. For those supervisors who have assigned qualified persons, ensure the provisions of Appendix 1 are implemented.
- c. Regularly inspect assigned work areas to identify and correct electrical hazards.
- d. Ensure that work on live electrical parts by their assigned qualified persons is avoided to the widest extent possible and then only done with prior coordination and approval from the Facility Safety Coordinator and Building Manager.
- e. Plan activities such that work will be performed in a de-energized state whenever possible.

Note: De-energizing and performing Lockout/Tagout to all potential hazardous sources of energy is the primary method of protecting people from serious injury. Although Lockout/Tagout will be identified in this chapter, the specific requirements for Lockout/Tagout are found in Chapter 12 Lockout/Tagout Program of this manual. Lockout/Tagout training will be conducted as outlined in Chapter 12.

- f. Supervisors shall ensure qualified person(s) (as defined above) who work with electrical equipment and systems are trained and comply with the specific training requirements outlined in 29 CFR 1910.332 and 1910.333, Subpart S (Electrical Standards); and National Electrical Code (NEC), NFPA 70E, Standard for Electrical Safety in the Workplace requirements.

- (1) Supervisors may use **Appendix 1, Attachment 2 Electrical Safety Training Checklist** as a guideline to help ensure safety training requirements for qualified persons are met.

- g. Maintain on file an updated list of qualified persons and ensure the facility safety coordinator and building manager receives a current listing.
- h. Conduct a workplace hazard assessment, as outlined in Chapter 4 of this manual, and identify all potentially hazardous electrical work activities within their area of responsibility and develop a JHA for each electrical work process. Contact the facility safety coordinator for assistance.
- i. Use **Appendix 1, Attachment 1 Energized Electrical Work Permit** and provide sufficient justification to Facility Safety Manager and Building Manager, when work on energized circuits or equipment cannot be avoided or deferred until the next scheduled outage.
- j. Ensure a JHA has been completed and reviewed by qualified persons conducting Energized Electrical Work, **Appendix 1, Attachment 3 Job Briefing and Planning Checklist** shall be used to document job safety briefing immediately prior to conducting the task.
- k. Ensure only Qualified Employees perform work on energized circuits or equipment.
- l. Ensure that all workers are properly protected by means such as instructions, signs, barriers, electrical personal protective equipment (PPE), and appropriate lock and tag devices.
- m. Foster an attitude and awareness of electrical safety in the people they supervise and see that individual safety responsibilities are carried out.
- n. Ensure defective electrical equipment is properly tagged “**DANGER-DO NOT OPERATE**” or equivalent tag that identifies the hazard potential.
- o. Review and forward completed copies of the Energized Electrical Work Permits to the building manager for record keeping.
- p. Maintain electrical equipment in good working order and ensure preventive maintenance is performed as required.

4. Employees

- a. Comply with all safety requirements and act proactively to prevent accidents and injuries by reporting electrical hazards to supervisors and/or safety coordinator promptly.
- b. Maintain a safe distance from electrical servicing activities and never attempt to remove or tamper with “**Lockout/Tagout**” tags or locks on equipment or

switches being serviced by authorized persons. Contact your supervisor if you have any questions about locked out equipment or switches in your work area.

- c. Test GFCI receptacles before each use; if unsure how to accomplish the test, ask your supervisor or safety coordinator for assistance.
- d. Report tripped circuit breakers to the supervisor so that the condition may be properly investigated by a qualified person. Never attempt to reset a tripped circuit breaker more than once, and only when there is a known overload condition (e.g. microwave and coffee pot used at the same time).
- e. Maintain a 36" clearance around circuit breaker panels and disconnects at all times so they may be readily accessible in the event of an emergency.
- f. Never remove "**DANGER-DO NOT OPERATE**" or '**OUT OF SERVICE**' tags from tagged-out defective equipment awaiting service or repair.
- g. Perform a visual inspection of electrical equipment before each use and report any deficiencies or suspected hazards to your supervisor, building manager, or safety coordinator.

5. Qualified Persons

- a. Abide by Appendix 1 of this chapter and follow safety-related work practices required by 29 CFR 1910.331 through 1910.335, NFPA 70E, that pertain to their respective job assignments.
- b. Become familiar with all potential electrical hazards in the area(s) in which they work. Learn and follow the appropriate electrical standards, procedures, and hazard-control methods.
- c. Consult with appropriate supervisors (your own supervisor and the supervisor of the hazardous system) before undertaking a potentially hazardous electrical operation, and then only after a JHA has been prepared to identify hazards and appropriate control measures.
- d. Notify a supervisor of any condition, person, or behavior which poses a potential electrical hazard.
- e. Wear and use appropriate electrical personal protective equipment (PPE).
- f. When permitted to work on or near exposed energized parts the Qualified Person shall:

- (1) Have the skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.
- (2) Have the skills and techniques necessary to determine the nominal voltage of exposed live parts.
- (3) Know the clearance distances when working on energized parts.
- (4) Review and sign **Appendix 1, Attachment 1 Energized Electrical Work Permit**, only after receiving all approvals (supervisor, safety coordinator, building manager) before conducting work on any energized parts.
- (5) Review the (JHA), and **Appendix 1, Attachment 3 Job Briefing and Planning Checklist** before conducting work on any energized parts.
- (6) Clean and inspect the work area for completeness after each job.

6. Contracting Officer's Technical Representatives (COTRs)

- a. COTR's shall ensure a safety plan from the contractor has been submitted and accepted prior to work commencing. The electrical safety portion of the safety plan shall include a review of existing electrical hazards, personal protective equipment/clothing requirements, safe work practice procedures, and emergency/evacuation procedures applicable to the work to be performed. Ensure contractor submits a Job Hazard Analysis and Energized Electrical Work Permit with justification if work is to be accomplished on energized circuits and/or equipment.
- b. Provide a copy of the contractor's Energized Electrical Work Permit to the Safety Coordinator, Building Manager and the OPS Security Manager before the work commences.
- c. Ensure electrical work performed by contractors has been inspected and checked for completeness by an electrical qualified person to ensure OSHA and National Electric Code compliance prior to acceptance.

E. GENERAL ELECTRICAL SAFETY -- HAZARD IDENTIFICATION AND CONTROL

1. General Electrical Hazard Prevention

- a. Adherence to OSHA Standards Subpart I (1910.132 – 1910.138) and Subpart S Electrical (1910.301 to 1910.399) is required.

- b. Disconnecting means (shutoff) for “hard wired” (i.e. non-cord and plug) electrical equipment shall be legibly marked to indicate their purpose unless located and arranged so the purpose is evident.
- c. Maintain 36 inches of clearance in front of circuit breaker panels and other equipment disconnect switches to ensure they are accessible in an emergency situation.
- d. Maintain electrical cover plates in-place on all switches and outlets.
- e. Live parts must be guarded to protect any person(s) from accidental contact. This includes locked enclosures accessible only to qualified persons for electric equipment operating at 50 volts or more.
- f. Work involving electrical equipment in wet and damp locations should not be performed unless it is absolutely necessary and should be postponed until the liquid can be cleaned-up. If this type of work is absolutely necessary to be accomplished in a “damp” location, the following special precautions must be incorporated:
 - (1) Only use electrical cords or outlets (receptacles) that have Ground Fault Circuit Interrupters (GFCIs) unless the branch circuit is protected by GFCI. Portable GFCI equipment will be tested in a dry location before use;
 - (2) Place a dry barrier over any wet or damp work surface;
 - (3) Remove standing water before beginning work. Use of electricity/electric equipment is prohibited in areas where there is standing water;
 - (4) Do not use electrical extension cords in wet or damp locations; and
 - (5) Keep electrical cords away from standing water.

2. Ground Fault Circuit Interrupters (GFCIs). GFCIs help protect against electrocutions that result from a ground fault.

- a. GFCIs (receptacles or branch circuits) shall be installed in locations as required by the current edition of the National Electric Code (NEC) and (NFPA 70), and 29 CFR 1910.304. Some common areas that require GFCI protection for receptacles include restrooms, garages, kitchens, rooftops, and receptacles within 6 feet of a sink.

- b. All outdoor receptacles accessible for use by visitors and members of the public will be GFCI protected.
- c. GFCIs must be used to protect individuals during indoor/outdoor demolition, construction, remodeling, maintenance, repair, and similar activities, either through branch circuit, temporary GFCI power connections, or portable GFCIs.
- d. GFCI receptacles (fixed or portable) shall have a test-before-use conducted by the individual user immediately prior to use. Check manufacturer instructions on testing procedure or check with your Facility Safety Coordinator. GFCI sample testing procedure:
 - (1) To test the receptacle GFCI, first plug a portable lamp or receptacle tester into the outlet. The light should be on. Then, press the "TEST" button on the GFCI. The GFCI's "RESET" button should pop out, and the light should go out.
 - (2) If the "RESET" button pops out but the light does not go out, the GFCI has been improperly wired. Contact an electrician to correct the wiring errors.
 - (3) If the "RESET" button does not pop out, the GFCI is defective and should be replaced.
 - (4) If the GFCI is functioning properly, and the lamp goes out, press the "RESET" button to restore power to the outlet.
 - (5) Every receptacle on the circuit that is wired in series with the GFCI shall be labeled "GFCI Protected" and tested using the testing procedures outlined above.

Note: GFCI receptacles that trip indicate there may be a potential problem and this should be reported. There is no such thing as "nuisance" tripping. If the GFCI is tripping, the leakage current is exceeding the built-in trip level, and the cause needs to be identified and corrected.
- e. Electrical outlets in locations not listed in the NEC but in wet and damp locations shall be GFCI protected. Receptacle-type GFCIs for use in wet and damp locations are identified by the words "Weather Resistant" or the letters "WR" where they (the words) will be visible after installation with the cover plate secured as intended. Weather-resistant receptacle-type GFCI's installed in wet

locations are intended to be installed with an enclosure that is weatherproof, whether or not the attachment plug cap is inserted.

- f. Circuit Breaker GFCIs should be tested monthly by a qualified person.

3. Use of Extension Cords (a type of flexible cord)

- a. Extension cords may be used to provide temporary power up to 90 days unless approved by the Facility Safety Coordinator and Building Manager for longer periods. If an extension cord is required for the same location on a continual basis, the task should be evaluated for the installation of additional receptacle(s), fixed wiring, or the relocation of equipment so that it can be plugged directly into a receptacle.
- b. Extension cords and flexible cords (such as on cord-and-plug connected equipment) must be visually inspected before each use for external defects such as loose parts, deformed and missing pins (such as ground prong) or damage to outer jacket or insulation, and for possible internal damage such as pinched or crushed outer jacket. Any defective cord or cord-and-plug-connected equipment must be tagged and removed from service and no person may use it until it is repaired and tested by a qualified person to ensure it is safe for use.
- c. Extension cords must be of the three-wire type with an equipment grounding conductor (ground prong/pin). Extension cords must be designed for hard or extra hard usage (for example, types S, ST, and SO). The rating or approval must be visible. Household type two prong extension cords are not allowed for use in the workplace at SI.
- d. Extension cords must be approved by a Nationally Recognized Testing Laboratory (NRTL) e.g., UL, NTS, CSA, CCL, WL etc.
- e. Extension cords and flexible cords must be protected from damage. Sharp corners and projections must be avoided unless protective measures such as covers are taken to protect the cord.
- f. Extension cords and flexible cords may not be run through windows or doors unless protected from damage, they must not create a trip hazard, and should only on a temporary basis and removed immediately when no longer in use.
- g. Extension cords and flexible cords may not be run above ceilings or inside or through walls, ceilings or floors, and may not be fastened with staples or otherwise hung in such a fashion as to damage the outer jacket or insulation.

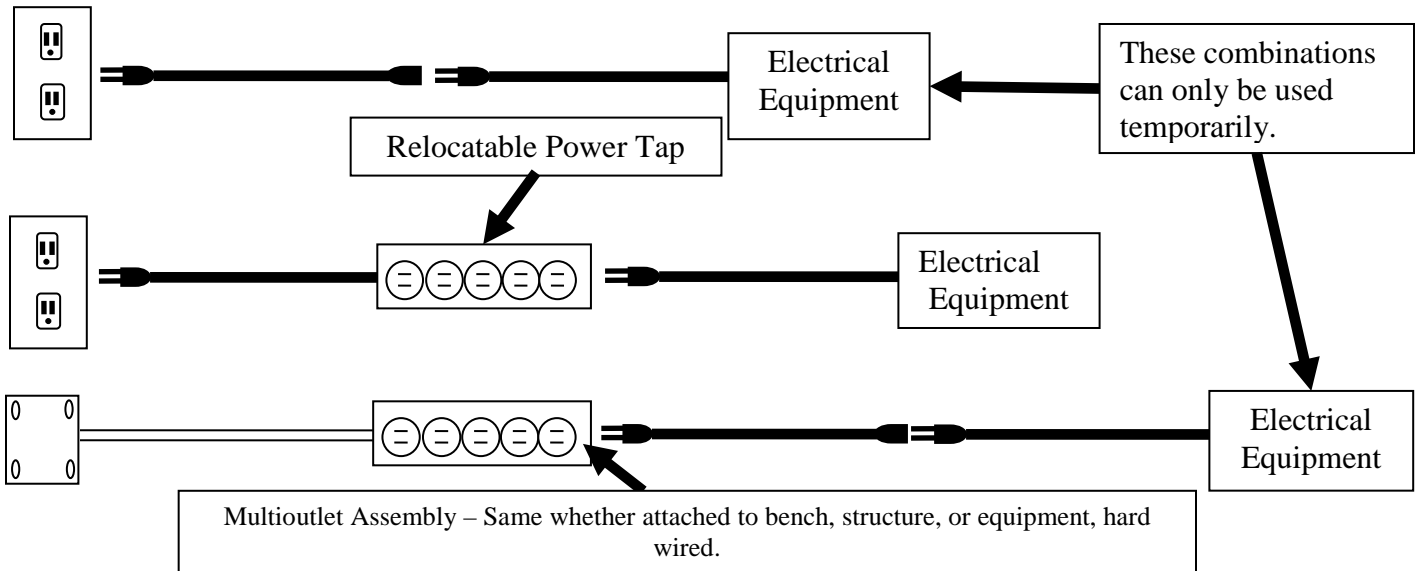
- h. Extension cords and flexible cords must be covered by a cord protector or caution tape when they extend into a walkway or other path of travel to avoid creating a trip hazard.
- i. Plugs and receptacles may not be connected or altered in any way that would interrupt the continuity of the equipment grounding conductor. Additionally, these devices may not be altered to allow the grounding pole to be inserted into current connector slots. Clipping the grounding prong from an electrical plug is prohibited.
- j. Adapter plugs are strictly prohibited with any electrical cord, plug or appliance.
- k. The following uses of extension cords are prohibited:
 - (1) Extension cords that are “daisy chained” (one extension cord plugged into another extension cord). **See Extension Cord & Power Strip Chart below.**
 - (2) Overloaded extension cords. The wire size must be sufficient for the current required.
 - (3) Extension cords with ground conductors that have less current-carrying capacity than the other conductors. (Equipment grounding conductors that are part of flexible cords or used with fixture wires shall not be smaller than 16 AWG copper and not smaller than the circuit conductors.)

4. Use of Relocatable Power Taps (RPTs) commonly called power strips or surge protectors.

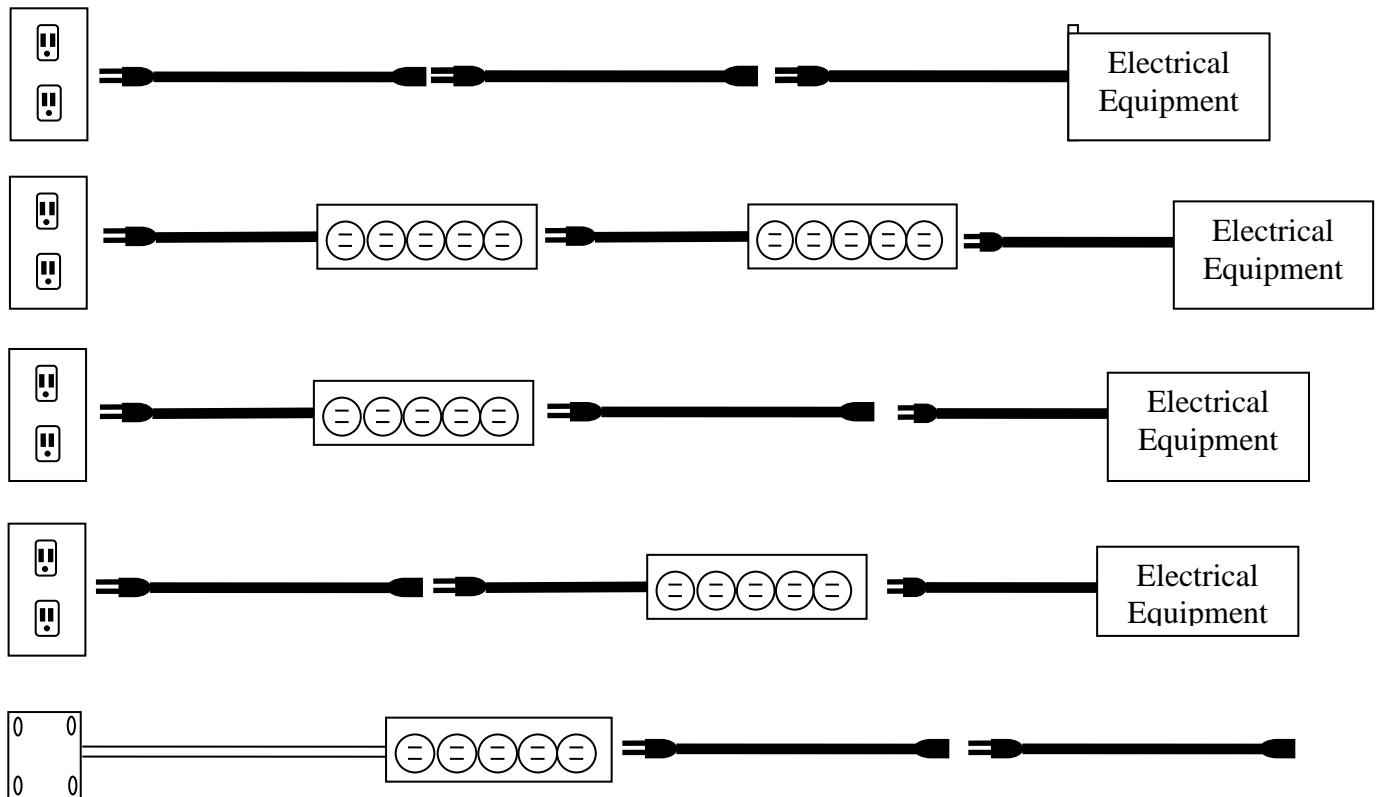
- a. RPTs are intended for indoor use as relocatable multiple outlet extensions of a single branch circuit to supply laboratory equipment, home workshops, home movie lighting controls, musical instrumentation, and to provide outlet receptacles for computers, audio and video equipment, and other equipment. **See Extension Cord & Power Strip Chart below.**
- b. RPTs are to be used within the manufacture’s guideline.
- c. RPTs must be approved by a Nationally Recognized Testing Laboratory (NRTL) i.e., UL, NTS, CSA, CCL, WL etc.
- d. RPTs must be plugged directly into a receptacle.
- e. RPTs that have surge protection status lights shall be visually inspected at least monthly for serviceability.
- f. The following uses of RPTs (power strips) are prohibited:

- (1) RPTs that are “daisy chained” (one power strip plugged into another power strip) or to an extension cord.
- (2) RPTs shall not be used for equipment drawing heavy loads, i.e. portable heaters, microwaves, air conditioners, refrigerators, coffee pots and water coolers, check manufacturer limitations or contact your Facility Safety Coordinator for additional information.
- (3) RPTs shall not be permanently mounted on building structures, walls, tables, work benches, and furniture, nor are they intended to be used as a substitute for fixed wiring.
- (4) The cords of RPTs are not intended to be routed through walls, windows, ceilings, floors or similar openings.
- (5) RPTs that are hot to the touch shall be disconnected and reported to the supervisor for further investigation by an electrician.

Acceptable combinations of extension cords & power taps



Unacceptable (Daisy Chain) combinations of extension cords & power taps



Note: Relocatable Power Taps (RPTs) are intended for indoor use as relocatable multiple outlet extensions of a single branch circuit to supply laboratory equipment, musical instrumentation, and to provide outlet receptacles for computers, audio and video equipment, and other equipment.

5. Use of Portable Electrical Power Tools and Equipment.

- a. Portable cord and plug connected equipment and associated flexible cords must be visually inspected before use on any shift for external defects such as loose parts, deformed and missing pins, or damage to outer jacket or insulation, and for possible internal damage such as pinched or crushed outer jacket. Any cord or cord-and-plug-connected equipment found defective must be removed and tagged “**DANGER – DO NOT OPERATE**” or similar tag that conveys a hazard warning, and no person may use it until it is repaired and tested by a qualified person to ensure it is safe for use.
- b. Portable equipment must be handled in a manner that will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.
- c. All portable electric equipment and flexible cords used in highly conductive work locations, such as those with water or other conductive liquids, or in places where employees are likely to contact water or conductive liquids, must be approved for those locations.
- d. All cord-and –plug connected equipment must be grounded with a correctly sized and identified equipment-grounding conductor that is an integral part of the power cord or cable. Exception: Listed equipment that is double insulated.

6. Office Appliances, Commercial Equipment and Components

- a. These units must be maintained in a safe working condition and approved for their intended use.
- b. Equipment covers and guards must be in-place during normal operation to ensure employees are not exposed to energized circuits, components, or connections.
- c. Defective office machines or equipment must be unplugged and labeled with an appropriate warning tag or sign until they can be properly repaired.
- d. Data and electrical wires shall be kept out of aisle ways and other walking or working surfaces to prevent tripping.
- e. Circuit Breakers in panel boards must be labeled to identify the equipment they control.
- f. Broken or cracked receptacles and switches shall be reported to the supervisor, facility building manager, or safety coordinator.
- g. Use of extension cords for appliances such as refrigerators and microwaves, is not permitted.

7. Light Fixtures

Lighting fixtures (bulbs) less than 8 feet above working surfaces must be guarded to prevent accidental contact and breakage of bulb via diffusers, cages, sleeves, etc. Those fixtures above working surfaces require a guard, regardless of height, if work operations in the area use materials or equipment that are able to strike or otherwise break lights (i.e. ladders, planks, pipe routinely accessed in the area).

F. SAFETY-RELATED ELECTRICAL WORK REQUIREMENTS FOR RESEARCH AND DEVELOPMENT LABORATORIES.

1. The requirements of this chapter apply to the electrical installations in those areas, with custom or special electrical equipment, designated for research and development (R&D) or as electrical laboratories.

Note: Laboratory and R&D equipment or systems can pose unique electrical hazards that might require special mitigation actions. Such hazards include AC and DC, low voltage and high amperage, high voltage and low current, large electromagnetic fields, induced voltages, pulsed power, multiple frequencies, and similar exposures. Refer to NFPA 70E, Article 350, for additional information.

2. The electrical system for R&D and laboratory applications shall meet the requirements of this chapter and conform to OSHA and NEC electrical installations as well as provisions outlined in Appendix 1 of this chapter.
3. The supervisor of each laboratory or R&D system application shall ensure the use of appropriate electrical safety-related work practices and controls are implemented. Periodic safety inspections (no less than annual) to include electrical safety, shall be conducted by the supervisor with assistance as needed from the Facility Safety Coordinator. The supervisor will monitor on-going work activities as they are in progress to ensure adequate safety procedures are in-place and are being followed.
4. Listing Requirements. The electrical equipment for systems used in the laboratory or R&D area shall be listed by a Nationally Recognized Testing Laboratory (NRTL) or field evaluated prior to use.
5. The laboratory supervisor shall ensure that laboratory workers are trained to the level of electrical hazard exposure as outlined in this chapter to ensure they are fully aware of electrical safe work procedures.

6. The supervisor will conduct a work assessment of tasks as outlined in Chapter 4 of this manual and ensure non-routine tasks and tasks that have high risk or high probability of an incident are outlined with an appropriate job hazard or standard operating procedure.

G. SAFETY-RELATED ELECTRICAL REQUIREMENTS FOR SPECIAL EVENTS.

1. Personnel coordinating the special event will ensure that the Life Safety requirements of Chapter 37 of this manual are completed as outlined.
2. Personnel coordinating the special event will ensure that the electrical wiring needed to support the event shall meet the requirements for electrical systems as outlined in 29 CFR 1910.301-305. Consult with the Facility Safety Coordinator, zone electricians, OSHEM, and OPDC electrical engineer as needed for assistance.
3. Temporary wiring. Except as specifically modified in this paragraph, all other requirements of 29 CFR 1910.301-305 for permanent wiring shall also apply to temporary wiring installations. Temporary electrical power and lighting installations of 600 volts, nominal, or less, may be used to support special events upon coordination with the Facility/Building Manager, Facility Safety Coordinator, OSHEM, and OPDC electrical engineer as necessary depending the size and nature of the event.
 - (a) Temporary wiring may be used for a period not to exceed 90 days for special events. Requests for use beyond 90 days should be referred to the Facility Safety Coordinator and the assigned OSHEM liaison.
 - (b) Temporary wiring will be deployed and protected to prevent damage to cords, plugs, etc. as well as ensuring that staff, visitors and members of the public are protected from inadvertent contact and tripping hazards. Elevated lighting and similar stanchions will be adequately secured from falling or being knocked over. Wiring used outdoors will comply with the OSHA requirements in 29 CFR 1910.303 and 304 for outside wiring to include the use of GFCI's. These issues shall be addressed in advance of the planned event.
 - (c) Temporary wiring shall be removed immediately upon completion of the project or purpose for which the wiring was installed.

H. TRAINING REQUIREMENTS

1. **Unqualified Persons** shall be trained in and familiar with any of the electrical safety –related work practices that pertain to their job assignments and which are necessary for their safety as outlined in their unit safety training matrix. Supervisors shall conduct a JHA for minor electrical work tasks (i.e. changing light bulbs), to help identify required safety training with assistance from the Safety Coordinator as necessary. General Electrical Safety Awareness training for staff should be conducted periodically, as outlined in Chapter 6, to highlight general workplace electrical safety hazard recognition and prevention techniques. Supervisors should discuss the restrictions of the type of work to be performed in their areas and when qualified persons should be referred to for specific electrical work.

I. RECORDS AND REPORTS

1. Building management shall maintain copies of **Appendix 1, Attachment 3 Energized Electrical Work Permit** for a minimum of 2 years.
2. The safety coordinator shall maintain general electrical safety training records for a minimum of 5 years. Training will be documented in the PeopleSoft database as outlined in Chapter 6 of this manual.
3. Supervisors shall maintain current inspection and test records of Electrical PPE used by qualified persons.

J. REFERENCES

1. OSHA 29 CFR 1910 Subpart I
2. OSHA 29 CFR 1910 Subpart S
3. NFPA 70, National Electrical Code (NEC)
4. NFPA 70E, Standard for Electrical Safety in the Workplace
5. Chapter 6, Training, SI Safety Manual
6. Chapter 12 Lockout/Tagout, SI Safety Manual
7. Chapter 37, Life Safety Program, SI Safety Manual
8. Arizona State University, Electrical Work Safety Program
9. Stanford University, Electrical Safety Program
10. College of Nanoscale Science & Engineering, Electrical Safety Program

K. ADDITIONAL ELECTRICAL SAFETY RESOURCES

- <https://www.osha.gov/SLTC/electrical/>
- https://www.osha.gov/SLTC/etools/construction/electrical_incidents/mainpage.html
- <http://www.esfi.org/>

Common Electrical Hazards PowerPoint, Chapter 16:

http://ofeo.si.edu/safety_health/training/docs/Chapter_16_Common_Electrical_Hazards.pptx

Appendix 1- Specific Work-Related Electrical Safety for Electrical Qualified Persons (Mandatory)

APPENDIX 1

SPECIFIC WORK-RELATED ELECTRICAL SAFETY FOR ELECTRICAL QUALIFIED PERSONS (MANDATORY)

A. ELECTRICAL WORK PRACTICES

1. Establishing an Electrically Safe Work Condition
2. Working on energized Parts
3. Approach Boundaries to Energized Conductor or Circuit Parts
4. Vehicular and Mechanical Equipment
5. Other Precautions for Personnel Activities
6. Personal and Other Protective Equipment
7. Training
8. References

ATTACHMENTS

Appendix 1, Attachment 1 Energized Electrical Work Permit
Appendix 1, Attachment 2 Electrical Training Checklist
Appendix 1, Attachment 3 Job Briefing and Planning Checklist

A. ELECTRICAL WORK PRACTICES

1. Establishing an Electrically Safe Work Condition.

- a. Determine all possible sources of electrical supply to the specific equipment.
- b. After properly interrupting the load current, open the disconnecting device(s) for each source.
- c. Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position.
- d. Apply lockout/tagout devices in accordance with Chapter 12 "Lockout/Tagout" of the SI Safety manual.
- e. Use an adequately rated voltage detector to test each phase conductor or circuit part and verify they are 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 voltage detector is operating satisfactorily.

- f. Where the possibility of induced voltage or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductor or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

2. Working on Energized Parts – SI Policy prohibits work on energized parts. Energized electrical conductors or circuit parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works within the Limited Approach Boundary of those conductor or parts.

a. Exceptions:

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

NOTE: Examples of work that might be performed within the limited approach boundary of exposed energized electrical conductors or circuit parts because of infeasibility due to equipment design or operational limitations include performing diagnostics and testing (e.g. start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized, and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment. **Under no condition is energized work to be performed in an electrically classified hazardous location.**

b. Energized Electrical Work Permit.

1. Where Required. When working on energized electrical conductors of circuit parts that are not placed in an electrically safe condition, work to be done shall be considered energized electrical work and shall be performed by written permit only. See **Attachment 1 Energized Electrical Work Permit.**

2. Exemptions to Energized Work Permit. Work performed within the limited approach boundary of energized electrical conductors or circuit parts by qualified persons related to tasks such as testing troubleshooting, voltage measuring, IR thermography, shall be permitted to be performed without an energized electrical work permit, provided appropriate safe practices (JHAs), and personal protective equipment (rated for the labeled/rated exposure) as outlined in OSHA 29 CFR 1010.137 and NFPA 70E are provided and used. This does not mean that testing and troubleshooting are any less hazardous. If the purpose of crossing the limited approach boundary is only for visual inspection and the restricted approach boundary will not be crossed, then an energized electrical work permit shall not be required.

3. Approach Boundaries to Energized Conductors or Circuit Parts.

- a. Shock Hazard Analysis. A shock hazard analysis shall determine the voltage to which personnel will be exposed, boundary requirements, and the personal protective equipment necessary in order to minimize the possibility of electric shock to personnel.
- b. Shock Protection Boundaries. The shock protection boundaries identified as Limited, Restricted, and Prohibited Approach Boundaries are applicable to the situation in which approaching personnel are exposed to energized electrical conductors or circuit parts. NFPA 70E, under *Approach Boundaries to Energized Conductors or Circuit Parts for Shock Protection*, will be referred to for the distances associated with various system voltages.
- c. Approach to Exposed Energized Electrical Conductors or Circuit Parts Operating at 50 Volts or More. No qualified person shall approach or take any conductive object closer to an exposed energized electrical conductor or circuit parts operating at 50 volts or more than the Restricted Approach Boundary set forth in 29 CFR 1910.133 and NFPA 70E. Exceptions are listed below.
 - (1) The qualified person is insulated or guarded from the energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves or insulating sleeves are considered insulation only with regard to the energized parts upon which work is being performed.

- (2) The energized electrical conductors or circuit part operating at 50 volts or more are insulated from the qualified person and from any other conductive object at a different potential.
 - (3) The qualified person is insulated from any other conductive object as during live-line bare-hand work.
- a. Approach by Unqualified Persons. Unqualified persons shall not be permitted to enter spaces that are required to be accessible to qualified employee only, unless the electric conductors and equipment involved are in an electrically safe work condition.
 - b. 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 of the work space where the electrical hazard exists shall advise the unqualified person(s) of the electrical hazard and warn them to stay out of the Limited Approach Boundary.
 - c. If the job requires qualified or unqualified persons who are not associated with the work task to be in the area, then barriers, signs, and/or an attendant shall be used to warn them of the hazards and to keep out of the area. This element also applies to work performed in public space such as offices, exhibit space, corridors, and outdoor areas.
 - d. Arc Flash Hazard Analysis. An arc flash hazard analysis shall determine Arc Flash Protection Boundaries and the personal protective equipment that employees within the Arc Flash Protection Boundary shall use. The arc flash hazard analysis shall be updated when a major modification or renovation takes place. It shall be reviewed periodically, not to exceed five years. To account for changes in the electrical distribution system that could affect the results of the arc flash hazard analysis. The arc flash hazard analysis shall take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance. Additional information is contained in NFPA 70E, Article 130.5.
 - e. In lieu of an arc flash hazard analysis, the arc flash boundary shall be permitted to be based on the appropriate table identified in the NFPA 70E for *Hazard/Risk Category Classifications and Use of Rubber Insulating Gloves and Insulated and Insulating Hand Tools-Alternating Current Equipment*. The assumed maximum short-circuit current capacities and maximum fault clearing times for various tasks are listed in

the table. For tasks not listed, or for power systems with greater than the assumed maximum fault clearing times, an incident energy analysis shall be required in accordance with NFPA 70E.

- f. Arc Flash Protection Boundary. The arc flash boundary for systems 50 volts and greater shall be the distance at which the incident energy equals 5 J/cm²(1.2 cal/cm²).
- g. Equipment Labeling. As a minimum, equipment shall be field marked with a label containing the available incident energy and the corresponding working distance, required level of PPE, nominal system voltage, and arc flash boundary.
- h. Test Instruments and Equipment Use. Only qualified persons shall perform testing work within the Limited Approach Boundary of energized conductors or circuit parts operating at 50 volts or more.

4. Vehicular and Mechanical Equipment.

- a. Elevated Equipment. Where any vehicle of mechanical equipment structure will be elevated near energized overhead lines, they shall be operated so that a distance of 10 feet is maintained. If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 feet. If the voltage is higher than 50kV, the clearance shall be increased 4 inches for every 10kV over that voltage. This type of operation will be included in a JHA and reviewed before the task is accomplished.
- b. Equipment Contact. Employees standing on the ground shall not contact the vehicle or mechanical equipment or any of its attachments, unless either of the following conditions applies.
 - (1) The employee is using protective equipment rated for the voltage.
 - (2) The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come close to the line that permitted in 29 CFR 1910.333 Table S-5. This will be address in the JHA or standard operating procedure.
- c. Equipment Grounding. If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a

possibility of overhead line contact. Additional precautions, such as the use of barricades, dielectric overshoe footwear, or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential).

5. Other Precautions for Personnel Activities.

a. Alertness.

- (1) **When Hazardous.** Employees shall be instructed to be alert at all times when they are working within the Limited Approach Boundary of energized electrical conductors or circuit parts operating at 50 volts or more and in work situations where unexpected electrical hazards might exist. This will be addressed as part of the JHA.
- (2) **When Impaired.** Employees shall not knowingly be permitted to work within the Limited Approach Boundary of energized electrical conductors or circuit parts operations at 50 volts or more or where electrical hazards exist, while their alertness is recognizably impaired due to illness, fatigue, or other reasons. Supervisors should monitor high risk electrical work activities to help ensure workers remain alert as well as looking for fatigue, illness, and other physical factors that could impair a worker's ability to work safely.
- (3) **Changes in Scope.** Employees shall be instructed to be alert for changes in the job or task that may 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. When unexpected changes occur, work will stop and the change in conditions addressed under a revised JHA.

b. **Blind Reaching.** Employees shall be instructed not to reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

c. **Illumination.** Employees shall not enter spaces containing electrical hazards unless illumination is provided that enables the employees to perform the work safely.

d. **Obstructed View of Work Area.** Where lack of illumination or an obstruction precludes observation of the work to be performed, employees shall not perform any task within the Limited Approach Boundary of energized electrical conductors or circuit parts, operating at 50 volts or more or where an electrical hazard exists.

- e. **Conductive Articles Being Worn.** Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, etc.) shall not be worn where they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.
- f. **Conductive Materials, Tools, and Equipment Being Handled.**
 - (1) **General.** Conductive materials, tools, and equipment that are in contact with any part of employee's body shall be handled in a manner that prevents accidental contact with energized electrical conductors or circuit parts. Such materials and equipment include, but are not limited to long conductive objects, such as ducts, pipes and tubes, conductive hose and rope, metal-lined rules, scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.
 - (2) **Approach to Energized Electrical Conductors or Circuit Parts.** Means shall be employed to ensure that conductive materials approach to exposed energized electrical conductors or circuit parts no closer than that permitted by NFPA 70E 130.2.
- g. **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 50 volts or more or an electrical hazard exists, management 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, 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 part rating at 50 volts or more or where an electrical hazard exists. This will be addressed on a task specific JHA and work shall be in compliance with Confined Space Entry, Chapter 15, SI Safety Manual.
- h. **Housekeeping Duties.** Where energized electrical conductors or circuit parts present an electrical contact hazard, employees shall not perform housekeeping duties inside the Limited Approach Boundary where there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact. Electrically conductive cleaning materials (including conducting solids such as steel wool, metalized cloth, and silicone carbide, as well as conductive liquid solutions) shall not be used inside the Limited Approach Boundary unless procedures to prevent electrical contact are followed. This will be addressed on a task specific JHA.

- i. 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 not of the load-break type, fuses, terminal lugs, and cable splice connections are not permitted to be used for such purposes, except in an emergency.

- j. Reclosing Circuits after Protective Device Operation. After a circuit is de-energized by 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 is 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.

- k. Portable ladders. Portable ladders shall have nonconductive side-rails if they are used where the employee or the ladder could contact exposed energized parts.

6. Personal and Other Protective Equipment.

- a. General. Employees working in areas where electrical hazards are present shall use protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed. **The specific personal protective equipment necessary for a task will be included on JHA's.** Supervisors should always refer to 29 CFR 1910.137 and NFPA 70E for additional regulatory requirements and electrical safe work practices.

- b. Care of equipment. Electrical protective equipment shall be maintained in a safe, reliable condition. The protective equipment shall be visually inspected before each use to ensure it is in serviceable condition. Protective equipment shall be stored in a manner to prevent damage from physically damaging conditions and from moisture, dust, or other deteriorating agents. Supervisors will ensure employees are trained on the use, care, and inspection of electrical protective equipment.

NOTE: Specific requirements for periodic testing of electrical protective equipment are given in the table below and are covered in 29 CFR 1910.37 and NFPA 70E.

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 gloves	Before first issue and every 6 months thereafter (*)
Rubber insulating sleeves	Before first issue and every 12 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.

- c. When an employee is working with the Arc Flash Protection Boundary, they shall wear protective clothing and other personal protective equipment.
- d. Movement and Visibility. When flame-resistant (FR) clothing is worn to protect an employee, it shall cover all ignitable clothing and shall allow for movement and visibility.
- e. Head, face, Neck, and Chin (Head Area) Protection. Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with energized electrical conductors or circuit parts from flying objects resulting from electrical explosion. Employees shall wear nonconductive protective equipment for the face, neck, and chin whenever there is a danger of injury from

exposure to electric arcs or flashes or from flying objects resulting from electrical explosion.

- f. Eye Protection. Employees shall wear protective equipment for the eyes whenever there is a danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.
- g. Body Protection. Employees shall wear FR clothing wherever there is possible exposure to an electric arc flash above the threshold incident-energy level for a second-degree burn.

NOTE: Such clothing can be provided as an arc flash suit jacket and arc flash suit pant, or as coverall, or as combinations of jacket and pant, or for increased protection, as coverall with jacket and pants.

- h. Hand and Arm Protection. Employees shall wear rubber insulating gloves with leather protectors where there is a danger of hand injury from electric shock due to contact energized electrical conductors or circuit parts. Employees shall wear rubber insulating gloves with leather protectors and rubber insulating sleeves where there is a danger of hand and arm injury from electric shock due to contact with energized electrical conductors or circuit parts. Rubber insulating gloves shall be rated for the voltage for which the gloves will be exposed. Hand and arm protection shall be worn where there is possible to flash burn.
- i. Alerting Techniques.

(1) Safety Signs and Tags. Safety signs, safety symbols, or accident prevention 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 29 CFR 1910.145.

(2) 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 electrical conductors or circuit parts. Conductive barricades shall not be used where it might cause an electrical hazard. Barricades shall be placed no closer than the Limited Approach Boundaries.

(3) Attendants. If signs and barricades do not provide sufficient warning and protection from electrical hazards, and attendant shall be stationed to warn and protect employees. The primary duty and

responsibility of an attendant providing manual signaling and alerting shall be to keep unqualified persons 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.

- (4) Look-Alike Equipment. Where work performed on equipment that is energized and placed in 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 shall be employed to prevent inadvertent contact with look-alike equipment.

7. Training Requirements

- a. Safety Training. Employees, who face a risk of electrical hazard that is not reduced to a safe level by the applicable electrical installation requirements, shall be trained to understand the specific hazards associated with electrical energy. They shall be trained in safety-related work practices and procedural requirements as necessary to provide protection from the electrical hazards associated with their respective job or task assignments. Employees shall be trained to identify and understand the relationship between electrical hazards and possible injury.

NOTE: Employees in occupations listed in the following table face such a risk and are required to be trained. Other employees who also may reasonably be expected to face comparable risk of injury due to electric shock or other electrical hazards must also be trained.

Typical Occupational Categories of Employees Facing a Higher Than Normal Risk of Electrical Accident

Occupation
Blue collar supervisors ¹
Electrical and electronic engineers ¹
Electrical and electronic equipment assemblers ¹
Electrical and electronic technicians ¹
Electricians
Industrial machine operators ¹
Material handling equipment operators ¹
Mechanics and repairers ¹
Painters ¹

Riggers and roustabouts ¹
Stationary engineers ¹
Welders ¹

Note1. Workers in these groups do not need to be trained if their work or the work of those they supervise does not bring them or the employees they supervise close enough to be exposed to parts of electric circuits operating at 50 volts or more to ground for a hazard to exist.

- b. Qualified Persons must be sufficiently trained to prevent injury as covered in the requirements of 29 CFR 1910.331 through 1910.335. Supervisors may use Attachment 2, Electrical Safety Training Checklist, as a guideline for minimum safety training requirements for Qualified Persons. Specific training should be noted in JHA's and training matrices and be tailored to the duties and authorized job tasks. NFPA 70E training will be conducted to coincide with periodic revisions of NFPA 70E, Standard for Electrical Safety in the Workplace. This training may be conducted by outside vendors or by in-house subject matter experts, such as Master Electricians.
- c. Escorts. This includes but not limited to security, IT, exhibits, zoological staff, facilities maintenance, COTR's, and any other personnel who will escort, observe, or provide assistance to electrical workers. They shall receive training appropriate to the hazards anticipated and procedures necessary to recognize hazards and take precautionary measures for electrical work being accomplished in their work area.
- d. Type of Training. The training shall be classroom or on-the-job, or a combination of the two. The degree of training provided shall be determined by the supervisor through a hazard assessment and task risk exposure(s) to the employee in collaboration with the Facility Safety Coordinator and OSHEM. The type of training should be developed to ensure that employees understand electrical safety requirements, hazard recognition, and protection techniques.
- e. Emergency Procedures. Electrical qualified persons exposed to shock hazards shall be trained in methods of release of victims from contact with exposed electrical conductors or circuit parts. Electrical qualified persons will be trained and kept current in first aid and emergency procedures to include Cardiopulmonary Resuscitations (CPR). Depending upon their duties, these personnel may need training in additional standards such as permit-required confined space entry. These additional training needs should be identified on JHA's and unit training matrices.

- f. Retraining. An employee shall receive additional training (or retraining) under any of the following conditions:
 - (1) When supervisor or safety observations indicate that employees are not complying with the safety-related work practices or when there are inadequacies in the employee's knowledge or use of these procedures.
 - (2) When new technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices that are different from those that are normally used.
 - (3) Whenever there is a change in electrical work operations that present a hazard about which an employee has not previously been trained.

- g. Training Documentation. Training shall be documented to indicate that each employee has received the training outlined above and as identified through JHA's and training matrices. This documentation shall be made when the employee demonstrates proficiency in the work practices involved and shall be maintained for the duration of the employee's employment. The documentation shall contain the topic of training, each employee's name, instructor/trainer, and dates of training. All training shall be documented as outlined in Chapter 6 of this manual. Training records must be maintained throughout the individual's employment with the SI.

8. References

- a. OSHA 29 CFR 1910 Subpart I
- b. OSHA 29 CFR 1910 Subpart S
- c. NFPA 70, National Electrical Code (NEC)
- d. NFPA 70E, Standard for Electrical Safety in the Workplace
- e. Chapter 6, Training SI Safety Manual
- f. Chapter 12, Lockout/Tagout, SI Safety Manual

ATTACHMENTS

Attachment 1, Energized Electrical Work Permit

Attachment 2, Electrical Training Checklist

Attachment 3, Job Briefing and Planning Checklist

ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job/Work Order Number _____

- (1) Detailed circuit/equipment/job location: _____

- (2) Description of work to be done: _____

- (3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: _____

Requester/Title

Date

PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DOING THE WORK:

**Check
when
Complete**

- (1) Detailed job description procedures to be used in performing the above detailed work: _____

- (2) Description of the Safe Work Practices to be employed: _____

- (3) Results of the Shock Hazard Analysis: _____

- (4) Determination of Shock Protection Boundaries: _____

- (5) Results of the Flash Hazard Analysis : _____

- (6) Determination of the Flash Protection Boundary: _____

- (7) Necessary personal protective equipment to safely perform the assigned task: _____

- (8) Means employed to restrict the access of unqualified persons from the work area: _____

- (9) Evidence of completion of a Job Briefing including discussion of any job-related hazards: _____

- (10) Do you agree the above described work can be done safely? (If *no*, return to requester)

Electrically Qualified Person

Date

Yes No

Electrically Qualified Person

Date

Yes No

PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

_____ Supervisor	_____ Date	_____ Project Manager (if applicable)	_____ Date
_____ Building Manager	_____ Date	_____ Safety Coordinator	_____ Date

Note: If applicable, furnish OPS Security Manager a copy of this permit **before** beginning work.

**ELECTRICAL SAFETY TRAINING
CHECKLIST**

TRAINING ITEM	✓
SCOPE AND TRAINING	✓
All employees who work on, near or with premises wiring, wiring for connections to supply, other wiring, and installation of optical fiber cable along with electrical conductors have been trained as either qualified or unqualified workers.	
1. Unqualified person have been trained in and are familiar with any electrically related safety practices not covered by this standard but necessary for their safety.	
2. Qualified persons trained in and familiar with:	
a) Skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.	
b) Voltage determination	
c) Clearance distances that must be maintained.	
d) Training conducted has been specific to the hazards to which the employee may or will be exposed and their particular job duties.	
SELECTION AND USE OF WORK PRACTICES	✓
1. Work practices used to prevent electric shock and other injuries address de-energized parts which may be energized.	
2. Work practices used to prevent electric shock and other injuries address exposure to energized parts.	
3. Procedure provided for work on or near exposed de-energized parts includes:	
a) Written procedures specific to the equipment or worksite.	
b) De-energizing equipment.	
c) Application of locks and tags.	
4. Working on or near exposed energized parts:	
a) All employees near enough to be exposed to a hazard have been trained, and are aware of the practices that must be followed to protect them from the hazard.	
b) Only qualified employees work on energized parts.	
c) Overhead lines de-energized and grounded prior to working near them or other protective measures used.	
d) Unqualified persons working near overhead lines are aware that they may not come past approach, or use conductive objects closer than, 10 feet for lines up to 50 kV, or 10 feet plus 4 inches for every 10 kV over 50 kV.	
e) Qualified persons are having a working knowledge of the allowable approach distances IAW 29 CFR 1910.133 and NFPA 70E	
f) Vehicle and mechanical equipment operators understand that they must maintain:	
i) A clear distance of 10 feet plus 4 inches for every 10 kV over 50 kV while working near energized overhead lines.	
ii) A clear distance of 4 feet plus 4 inches for every 10 kV over 50 kV while in transit.	
iii) Insulating barriers are used and installed as required.	
iv) Insulated aerial lift operated by a qualified person must comply with the distances shown in 29 CFR 1910.133 and NFPA 70E	

**ELECTRICAL SAFETY TRAINING
CHECKLIST**

	√
SELECTION AND USE OF WORK PRACTICES	√
v) Employees standing on the ground understand they may not contact the vehicle unless using protective equipment rated for the voltage or the equipment located so no uninsulated part can provide a conductive path to persons on the ground.	
SELECTION AND USE OF WORK PRACTICES	√
g) Illumination is provided at all worksites to assure safe work.	
h) Protective shields and barriers provided and used for work in confined spaces to prevent contact with exposed energized parts.	
i) All conductive materials such as pipes, rods, etc. are handled so as to prevent contact with exposed energized parts.	
j) Conductive articles of clothing and jewelry such as watches, rings, etc. are not worn if they might contact exposed energized parts unless rendered nonconductive.	
k) Portable ladders with nonconductive side rails are used when working near or on exposed energized conductors.	
l) Housekeeping conducted only when exposed energized parts may not be contacted. Barriers provided and nonconductive cleaning materials used.	
m) Only qualified persons allowed to defeat electrical interlocks on temporary basis while they work on equipment.	
USE OF EQUIPMENT	√
1. Portable electric equipment such as cord-and-plug connected equipment, including flexible cords:	
a) Handled in a manner to avoid damage.	
b) Not used to raise or lower equipment.	
c) Not fastened with staples or hung so as to damage insulation.	
d) Visually inspected before each use on each shift.	
e) Defective items removed from service and not used until rendered safe.	
f) Plugs and receptacles mate properly.	
g) Flexible grounding-type cords have a grounding conductor.	
h) Grounding plug not defeated.	
i) Adapters which interrupt grounding continuity not used.	
j) Approved equipment used for work in conductive work locations (e.g. wet locations, etc.).	
k) Locking-type connectors are properly secured after connection.	
ELECTRIC POWER AND LIGHTING CIRCUITS	√
1. Only load rated switches or circuit breakers used as disconnecting means.	
2. Circuits not manually reenergized until it is determined that it is safe to do so.	
3. Over-current protection of circuits not modified.	
TEST INSTRUMENTS AND EQUIPMENT	√
1. Used by qualified persons only.	
2. Visually inspected before use.	
3. If circuit tested is over 600 volts, nominal, test instrument tested for proper operation before and immediately after the test.	
4. Test instrument rated for the circuit to be tested and appropriate for the environment.	
5. Electrical equipment capable of igniting flammable or ignitable materials not used if present in the worksite.	

**ELECTRICAL SAFETY TRAINING
CHECKLIST**

SAFEGUARDS FOR PERSONNEL PROTECTION	v
1. Protective equipment used when there is exposure to potential electrical hazards.	
2. Protective equipment maintained in safe and reliable condition and tested and inspected as required.	
SAFEGUARDS FOR PERSONNEL PROTECTION	v
3. Protective equipment protected from damage during use.	
4. Approved electrically rated hardhats used as needed to protect head from electric shock or burns.	
5. Safety glasses or goggles used as needed to protect eyes or face when there is a danger of arcs, flashes or flying objects.	
6. Approved gloves worn that are appropriate for the hazard present	
7. Insulated tools or handling equipment used when conductors may be contacted.	
8. Insulated fuse handling equipment used to remove or install fuses when terminals are energized.	
9. Ropes and hand lines used near energized parts are nonconductive and are protected from moisture.	
10. Protective shields, barriers or insulating materials are used to protect employees working near exposed energized parts.	
ALERTING TECHNIQUES	
1. Safety signs and tags used when necessary to warn employees about electrical hazards.	
2. Barricades used with safety signs when necessary to prevent or limit employee access to work areas with uninsulated energized conductors or parts.	
3. Attendants stationed as needed to warn when signs or barricades are not sufficient to prevent unauthorized access.	
Work Area:	
Employee Name:	

Job Briefing and Planning Checklist

Date _____ Job/Work Order # _____ Job Location _____

Description of Workscope _____

Supervisor _____ Employee(s) _____

IDENTIFY	
<input type="checkbox"/> The hazards <input type="checkbox"/> The voltage levels involved <input type="checkbox"/> Skills required <input type="checkbox"/> Any “foreign” (secondary source) voltage source <input type="checkbox"/> Any unusual work conditions	<input type="checkbox"/> Number of people needed to do the job <input type="checkbox"/> The shock protection boundaries <input type="checkbox"/> The available incident energy <input type="checkbox"/> Potential for arc flash (Conduct an arc flash-hazard analysis) <input type="checkbox"/> Arc flash protection boundary
ASK	
<input type="checkbox"/> Can the equipment be de-energized? <input type="checkbox"/> Are backfeeds of circuits to be worked possible?	<input type="checkbox"/> Is a “standby person” required?
CHECK	
<input type="checkbox"/> Job plans <input type="checkbox"/> Single-line diagrams and vendor prints <input type="checkbox"/> Status board <input type="checkbox"/> Is information on facility & vendor resources up to date?	<input type="checkbox"/> Safety procedures <input type="checkbox"/> Vendor information <input type="checkbox"/> Individuals are familiar with the facility <input type="checkbox"/> Job Hazard Analysis completed & reviewed
KNOW	
<input type="checkbox"/> What the job is <input type="checkbox"/> Who else needs to know - Communicate	<input type="checkbox"/> Who is in charge
THINK	
<input type="checkbox"/> About the unexpected event...What if? <input type="checkbox"/> Lock – Tag – Test – Try <input type="checkbox"/> Test for voltage – FIRST <input type="checkbox"/> Use right tools & equipment, including PPE	<input type="checkbox"/> Install and remove grounds <input type="checkbox"/> Install barriers and barricades <input type="checkbox"/> What else...?
PREPARE FOR AN EMERGENCY	
<input type="checkbox"/> Is the “standby person” CPR trained? <input type="checkbox"/> Is the required emergency equipment available? Where is it? <input type="checkbox"/> Where is the nearest telephone? <input type="checkbox"/> Where is the fire alarm? <input type="checkbox"/> Is confined space rescue available?	<input type="checkbox"/> What is the exact work location? <input type="checkbox"/> How is the equipment shut off in an emergency? <input type="checkbox"/> Are the emergency telephone numbers known? <input type="checkbox"/> Where is the fire extinguisher? <input type="checkbox"/> Are radio communications available?