

UC Merced

Electrical Safety Program



UC Merced Electrical Safety Program

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UC Merced - Electrical Safety Program

Lead: Mal Donohue EHS Director

Phone: (209) 5228-4234

E-mail: mdonohue@ucmerced.edu

Electrical Safety Program

1. Purpose & Introduction

More than 3,600 disabling electrical contact injuries occur in the workplace and more than 2,000 workers are sent to burn centers with electric burns every year in the U.S. Every day one person dies from electrical incidents.

This program guides safe-work policy and procedures for all electrical work at UC Merced (UCM). All faculty, staff, students, visitors and contractors must comply with the requirements of this program as it ensures their safety by:

- Defining safe work practices and use requirements for all people who work with electrically energized equipment as part of their normal job duties.
- Establishing training requirements for qualifying and authorizing UCM employees who work on or near energized electrical circuits and components.
- Establishing a process for evaluating the hazards of every potentially energized electrical work task and for determining appropriate hazard controls.
- Establishing a formal process for ensuring safe electrical work through a safe electrical equipment and contract services procurement approval process.

2. Applicability & Scope

This program applies to any electrical work at UC Merced when someone:

- Conducts testing or repairing of electrical or electronic equipment.
- Works on or adjacent to electrical distribution and hard-wired electrical equipment.
- Designs, builds, or modifies electrical or electronic equipment.
- Procures by UCM purchase requisition or contract some type of electrical / electronic contract work or equipment.
- Supervises personnel or contractors who perform electrical / electronic work.

This Electrical Safe Work Program provides the minimum knowledge of safe-work practices necessary to guide the work noted above and prevent electrical shock, burns or property loss. **Reading this program does not qualify the reader to perform electrical work.** Safe-work practices beyond the scope of this program must be established for each work area by responsible persons and at minimum must include the safety concerns, policies and procedures outlined by this program.

3. Roles & Responsibilities

Everyone is responsible for their own safety and that of their coworkers through knowledge and application of safe-work practices, procedures and use of safe-work equipment at a level appropriate to the hazards encountered in their workplace. Toward that end, the following personnel must demonstrate and act according to their level of responsibilities:

All Faculty, Staff and Students must:

- Stop immediately any activity believed to be hazardous. Everyone at UCM has this authority and obligation to speak up and stop unsafe work.
- Perform electrical work only when the electrical hazards are identified, adequately controlled, and when they are properly trained to perform safe-work tasks.
- Attend required training to achieve understanding of how to work safely and to respond to abnormal or emergency situations.
- Do no work requiring specialized training if they are not current in their required training without appropriate prior approval from their manager, supervisor, PI, etc.
- Notify their manager, supervisor, PI, etc. of any condition or behavior that poses a potential hazard.
- Wear and use appropriate personal protective equipment (PPE).
- Immediately report any occupational injury or illness from an electrical shock to their manager, supervisor, PI, etc. regardless of how minor the shock is perceived to be.
- Assure that you have been trained per the requirements of this program by reading and understanding these responsibilities.
- Only use electrical extension cords according to the guidelines of Attachment O.

Supervisors

Of electrical workers and persons potentially exposed to energized conductors must:

- Be familiar with the responsibilities of All Faculty, Staff and Students in the application of the Electrical Safety Program in their work.
- Establish, implement, and maintain procedures and/or work practices that ensure safe electrical work by their subordinates as outlined in the Safe-Work Procedures section of this program at minimum.
- Maintain a safe work environment for all locations under their jurisdiction.
- Take corrective action to control any potentially hazardous operation or condition.
- Ensure that approved, maintained, and tested personal protective equipment and clothing is provided, available, and used properly by their subordinates.

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- Assign only “Authorized or Qualified” personnel to perform electrical work.
- Ensure that employees understand how to work safely by personally conducting a pre-job briefing as necessary.
- Ensure that work-routines, inspections, or surveillances conducted within the Limited, Restricted, or Prohibited approach boundaries are conducted by personnel qualified to work within those spaces.
- Ensure that all injuries are treated promptly and reported to Workers Compensation and EH&S within 8 hours of occurrence.
- Assure that you have been trained per the requirements of this program.

Assistant Vice Chancellor of Facility Services

- Be familiar with the responsibilities of All Faculty, Staff and Students in the application of the Electrical Safety Program in their work.
- Interprets the California Electrical Code as it applies to existing and new UCM facilities. The AVC may delegate this authority to the PP-CS Electrical Engineer, consulting project engineers, or other qualified professionals as need may dictate.
- Delegates a qualified Management Representative to charter and Chair the Electrical Safety (NFPA70e) Committee (EISC).

Director - Environment, Health and Safety (EH&S) is responsible for establishing and maintaining the Electrical Safe Work Program, providing affected persons with information and training on its content, and monitoring compliance by persons performing electrical work and their supervisors. In addition, the Director must be familiar with the responsibilities of All Faculty, Staff and Students in the application of the Electrical Safety Program in their own work.

EH&S Safety Specialist

Campus Safety Specialist is the authorized representative of the Director - EH&S and has the responsibility to ensure the acceptability of non-facility (experimental) electrical wiring and apparatus. The Safety Specialist Engineer must:

- Be familiar with the responsibilities of All Faculty, Staff and Students in the application of the Electrical Safety Program in their work.
- Conduct periodic assessments of electrical safe work program compliance at UCM and provide feedback, incident reports and recommendations to the Electrical Safety Committee.
- Maintain documentation of electrical safe work policies and procedures for all UCM operations.
- Provide technical support for the UCM electrical safe work program
- Be a permanent member of the UCM Electrical Safety Committee.
- Evaluate existing workplace safety by inspecting, or directing the inspection of, the workplace for California Electrical Code (CEC) and CalOSHA compliance.
- Have access to, and provide non-facility safe-work electrical inspection services for, all UCM workplaces including research and leased operations.
- Provide assistance to academic departments by evaluation, or directing the evaluation, of the acceptability of experimental electrical wiring and apparatus.

Ensure electrical safety training course content complies with this Program, and ensures qualified trainers are available as needed.

- Develop and revise electrical safety training as necessary.
- Review drawings, tests, and other documentation provided by project engineers, principal investigators (PIs), or other responsible persons for compliance with accepted safety criteria and code intent.
- Consult with the appropriate specialists to verify that engineering, design, and construction requirements have been correctly applied.
- Conduct other inspections and analyses as necessary to verify the compliance and acceptability of the apparatus involved.
- Serve as the first contact Authority Having Jurisdiction (AHJ), providing professional interpretations of CalOSHA electrical safety requirements, and as liaison with Regulatory Agencies regarding Electrical Safe Work within UCM.
- Assist the PPCS Electrical Engineer for interpretation and application of the NFPA 70, "The National Electrical Code", etc.
- Work with Capital Projects to maintain and update the sections of this program that impact building design / construction.
- Provide administrative and technical support as necessary and may be requested by the Electrical Safety Committee Chair to ensure the effective operation of this Committee.

4. Definitions

Accessible (equipment) - Admitting close approach; not guarded by locked doors, elevation, or other effective isolation means.

Accessible (readily) - Location or equipment capable of being reached quickly for actuation or inspection without requiring personnel to climb over or remove obstacles or to resort to portable ladders, etc.

Acronyms used in this program are:

- AHJ: Authority Having Jurisdiction
- ANSI: American National Standards Institute
- AWG: American Wire Gauge
- CalOSHA: California Occupational Safety and Health Administration
- CEC: California Electrical Code (2007)
- EH&S: Environment, Health & Safety
- EI/LOTO: Energy Isolation - Lockout/Tagout
- EISC: Electrical Safety Committee
- ETL: Inertek Testing Services (formerly ETL Testing Laboratories)
- FM: Factory Mutual
- J: Joules (watt-seconds)
- JHA: Job Hazard Analysis
- mA: Milliampere
- NEC: National Electrical Code also known as NFPA 70.

NESC: National Electrical Safety Code

NFPA: National Fire Protection Association

NFPA 70: National Electrical Code also known as the NEC.

NFPA 70E: Standard For Electrical Safety in the Workplace

NRTL: Nationally Recognized Testing Laboratory (e.g. UL = Underwriter's Laboratory)

PPE: Personal Protective Equipment

SRC: Safety Review Committee

UCM: University of California Merced

UL: Underwriters Laboratories

V: Volts

W: Watts

Approved - Acceptable to the "Authority Having Jurisdiction" (AHJ).

Arc Blast - An explosive release of molten material and shock-wave from equipment caused by high-amperage arcs / plasma.

Authority Having Jurisdiction (AHJ) - A term used to define roles or responsibilities within this program for various regulatory agencies, NRTLs, campus departments and UCM personnel who are referenced or given authority by this program document and/or its application.

Authorized Person - A qualified person delegated by their supervisor to perform specific duties under work hazard conditions known to that supervisor. An authorized lockout tagout employee is a person who has completed the required hazardous energy control training and is authorized to lockout or tagout a specific machine or equipment to perform service or maintenance.

Conductive - Able to carry electric current.

Contractor - A general term used to define any outside individual, employer, business, or agency that is hired by UCM to conduct any type of electrical work on UCM facilities or equipment, or who conducts ancillary electrical work as part of fulfillment of a contract for any UCM Department or operation.

De-energized - Free from any electrical connection to a source of potential difference and from electrical charge. This condition is otherwise known as "not having an electrical potential different from that of the earth or ground".

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

Electrical Safety - Recognizing hazards associated with the use of electrical energy and taking precautions so those hazards do not cause property loss, injury or death.

Electrically Safe Work Condition (see also “verified de-energized”) - A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with the Energy Isolation /LOTO Program, tested to ensure the absence of voltage, and grounded if determined necessary.

Enclosed (equipment / conductors) - Surrounded by a case, housing, fence, or wall(s) that prevents persons from accidentally contacting energized parts.

Energized (see also “Live Parts” or “Live work”) - Electrically connected to or having a source of voltage.

Exposed (as applied to live parts) - Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts that are not suitably guarded, isolated, insulated, or enclosed.

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

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

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

Guarded - Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

Live work – Physically working on or nearby electrically energized equipment and parts without barriers, guards or physical safe-guards in place.

Insulated - Separated from other conducting surfaces by a dielectric material (including air space) offering a high resistance to the passage of electric current.

Isolated Equipment - Equipment that has been de-energized and “locked-out” according to the UCM EI/LOTO Program procedures.

Labeled - Equipment or materials to which has been attached a label, symbol, or other identifying mark of a “Listing” organization (such as an NRTL) that is acceptable to the AHJ. Labeled equipment requires third-party product evaluation and periodic inspections of production of labeled equipment or materials, and by such labeling the manufacturer indicates compliance with appropriate standards of equipment performance and safety in a specified manner.

Limited Approach Boundary - A distance from an exposed live part within which an electrical shock hazard exists for non-qualified personnel, unless escorted by a qualified worker. The Limited Approach Boundary determines the minimum safe distance for the placement of barricades for shock protection. An unqualified worker may not enter the limited approach boundary without escort by a qualified worker.

Listed - Equipment, materials, or services included in a list published by a “Listing” organization that is acceptable to the AHJ and is concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material or services either meets appropriate designated standards or has been tested and found suitable for a specific purpose. “Listed” equipment will have the stamp of an NRTL or “Listing Organization.”

Listing Organization – See “Nationally Recognized Testing Laboratory”.

Live Parts (see also energized) - Energized conductive components. Also known as “Hot Parts” or “Electrically Hot”.

Nationally Recognized Testing Laboratory (NRTL) - Certain private sector organizations recognized by OSHA as an NRTL. That recognition signifies that the organization has met the necessary qualifications specified in the OSHA NRTL program. The NRTL determines that specific equipment and materials (products) meet consensus-based standards of safety to provide assurance that these products are safe for use in the U.S. workplace. E.g. Underwriters Laboratory (UL) is an NRTL.

Overload - Operation of equipment in excess of normal, full-load rating or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Qualified person - A person who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved. “Qualified Workers” are those specially trained to work on live electrical equipment or potentially live equipment under NFPA 70e. Qualified workers must protect themselves against all electrical hazards including shock, arc flash, burns and explosions. Training and demonstrated skills are required. Even an experienced electrician is not “qualified” in OSHA’s eyes unless the employer can show proof of the appropriate training, demonstrated skills and certifications.

Supervisor - This is a general term used throughout this program that is defined as a person who oversees electrical work, and persons doing electrical work, and who have the primary responsibility of ensuring a safe working environment. At UCM, ‘supervisors’ may include PIs, Researchers, Staff, Project Managers and / or Contractors.

Shock Hazard - A dangerous condition associated with the possible release of energy caused by contact or approach to live parts.

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Verified De-energized (see also “electrically safe work condition”) - A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with the Energy Isolation /LOTO Program, tested to ensure the absence of voltage, and grounded if determined necessary.

Voltage (of a circuit) - This is the greatest root-mean-square (rms) difference of electrical potential between any two conductors of a circuit.

Voltage to Ground - For grounded circuits, this is the voltage between the given conductor and the part of the equipment / circuit that is grounded. For ungrounded circuits, this is the greatest voltage between the given conductor and any other conductor of the circuit.

Working Near (energized / live parts) - Any activity inside a Limited Approach Boundary.

Working On (energized / live parts) – Conducting “Live work” using insulated tools, probes, or test equipment to physically contact energized equipment / circuits, regardless of the personal protective equipment a person is wearing on their hands, feet, or other body parts.

5. Electrical Hazards and Controls

For basic information about Electricity and Electrical Safety, please review the “Frequently Asked Questions / Fact Sheet” to become familiar with electrical hazards and controls.

5a. Electrical Hazards associated with work around electricity include:

Arc Flash

When an electric current passes through the air between two conductors, the temperature can reach 35,000°F. Exposure to these extreme temperatures can result in life threatening burns. The majority of hospital admissions due to electrical accidents are from arc-flash burns, not electrical shocks. Arc- flashes can and do kill at distances in excess of 10 ft.

Arc Blast

The tremendous temperatures of the arc cause an explosive expansion of both metal and the surrounding air in the arc path. For example, copper expands by a factor of 67,000 times when changed from a solid into a vapor. The dangers of this explosion are of a high blast pressure wave, high decibel levels of sound and high velocity shrapnel. The material and molten metal is expelled away from the arc at speeds exceeding 700 miles per hour. Arc blasts often cause severe injuries and death. Temperature from an arc flash may be as high as 35,000 Fahrenheit.

Burns

Burns suffered in electrical accidents are of two basic types: electrical burns and thermal contact burns. Electrical burns cause tissue damage to skin and internal tissues because the body is unable to dissipate the heat generated by current flowing through the body tissues. Typically, these burns are slow to heal. Thermal contact burns are those normally experienced from skin contact with the hot surfaces of overheated electric conductors.

Delayed Effects

Damage to the internal tissues may not be apparent immediately after contact with electricity. Delayed internal tissue swelling and irritation are possible. Prompt medical attention can help minimize these effects and avoid death or long-term injury.

Electrical Shock Hazards

Accidental contact with exposed electrical parts operating at a voltage greater than 50 volts to

ground and having a current greater than 5 milliamperes can cause serious injury or death. Fatal ventricular fibrillation of the heart can be triggered by a current flow of as little as several milliamperes. Severe injuries, such as internal burns, can occur even if the electricity does not pass through the vital organs or nerves.

5b. Hierarchy of Electrical Hazard Controls.....includes the following in order of effectiveness:

- Eliminate the hazard through application of the UCM Energy Isolation/Lock Out-Tag Out Program.
- Mitigate the hazard by using engineering controls, such as “Listed” panels, shields or barriers, to isolate personnel from the energized components.
- Reduce exposure to the hazard by using special tools such as double-insulated hand-tools, fused instrument probes, and personal protective equipment (PPE) to protect personnel from exposed hazardous electrical conductors.
- Apply administrative controls, such as the Electrical Live work Permit, Shutdown Request, or Switching Procedure, assignment of a Safety Watch, and qualification training.

5b1. Energy Isolation / Lockout Tagout Program (EI/LOTO)

De-energizing exposed electrical components is the preferred and primary method of electrical hazard control at UCM. The UCM Energy Isolation / Lock-out Tag-out Program details the procedures for de-energizing and locking out all sources of energy prior to working on any electrical equipment.

5b2. Engineering Controls

Engineering controls are the primary control measure used to reduce the potential for direct contact with exposed and energized electrical components. Engineering controls include, but are not limited to the following:

- Opaque or transparent non-conductive panels used as barriers. These barriers can have small openings for tool access to allow troubleshooting, measurement, and/or calibration of equipment with access panels open. This arrangement may also allow the safety interlocks to be closed without installation of bypass circuitry.
- Rated non-conductive insulating shields or barriers for energized components that do not need to be manipulated during the work.
- Ground Fault Circuit Interrupters (GFCI's) to supply temporary power during construction, remodeling, maintenance, repair, or demolition of buildings, structures, equipment or similar activities. As required by the CEC, GFCI's are used for all portable power tools, outdoor work, work on or near conductive surfaces, for resistive heating elements such as heater tapes, wet locations, rooftops, within 6 feet of any wet sink, bathrooms, kitchen, lab showers and eye-wash stations, and other areas that could present an electrical shock hazard should the worker come in contact with the energized conductor of a tool or instrument.
- Rated insulated barrier mats, floor coverings or gratings to isolate the worker from conductive ground paths while working on exposed and energized electrical components.

5b3. Personal Protective Equipment (PPE)

Qualified workers who are potentially exposed to electrical hazards that cannot be controlled through EI/LOTO or some engineering means are provided with and properly use tooling and personal protective equipment that is appropriate for the specific work to be performed and the associated hazard level. PPE may include isolative gloves, face protection, flame-resistant clothing, insulated tools, non-conductive shoes, insulated floor mats, etc.

5b4. Administrative Controls

Electrical safe work practices are applied during analysis, diagnostic, troubleshooting, and manipulative work on energized equipment by a qualified person, having been trained and briefed by a knowledgeable supervisor prior to commencement of the specific tasks the Supervisor/Project Manager authorizes. Work is only performed on energized electrical circuits or components when it is demonstrated that de-energization introduces additional or increased hazards, or is infeasible due to equipment design or operational limitations. If work must be done “hot”, then application of the “live work permit” process outlined in Appendix 1 of this program must be followed.

6. Electrical Safe Work Policy and Procedures

UCM's Electrical Safe Work Policy is as follows:

- All staff, project managers, contractors and employees ensure they and others around them are working in a safe manner. Everyone supports a "Stop Work Policy". It is the responsibility of everyone to exercise this policy when observing unsafe work conditions or practices.
- UCM complies with CalOSHA regulations, the California Electrical Code and other established safety standards to reduce or eliminate the dangers associated with working with or around electrical energy.
- All electrical wiring and equipment complies with the California Electrical Code and CalOSHA regulations for electrical safety and engineering.
- Work on or near equipment operating within the electrical hazard conditions identified in this document is performed in an electrically safe state (verified de-energized) or is formally approved and documented through an "Electrical Live work Permit" process. UC Merced is very unlikely to issue an "Electrical Live work Permit." See EHS if one is needed as there are very specific, stringent requirements.
- Anyone at UCM who works on or near hazardous energized electrical circuits or components must be a "Qualified Person" prior to performing such work.
- Energized parts that operate at less than 50 volts and less than 1000 watts are not required to be de-energized if there will be no exposure to electrical burns or to explosion blast due to electric arcs.
- When work on energized electrical circuits or components operating at voltages greater than 50 volts to ground and capable of an electrical current greater than 5 milliamperes is justified and approved, engineering controls (guards, covers, shields, insulated tools, fused probes, remote methods, etc.) and personal protective equipment is used to reduce the potential for contact with energized components.
- All research or test devices operating at a voltage greater than 50 volts or storing more than 1000 watt/seconds (joules) is protected by an enclosure with secured or interlocked covers, or isolated in a manner that will prevent inadvertent contact with exposed live parts.
- Fabrication of research and test equipment is done following UCM design and engineering review as prescribed in the Electrical Safe Work Program.
- All electrically energized equipment is used in a safe manner as intended by the manufacturer and within the equipment's NRTL listing.

6a. Electrical Safe Work – Administrative Procedures

“Qualifying” and “Authorizing” Personnel

Only those persons who are both “qualified” and “authorized” may install, fabricate, repair, test, calibrate, or modify electrical or electronics wiring, devices, systems, or equipment on UCM facilities or property.

Both Cal-OSHA and OSHA defines “Qualified Workers” as those specially trained to work on live electrical equipment. Qualified workers must protect themselves against all electrical hazards including shock, arc flash, burns and explosions. Training is key. Even an experienced electrician is not “qualified” in OSHA’s eyes unless the employer can show proof of the appropriate training and certifications.

CA - OSHA and Federal OSHA require unqualified workers to be trained in the electrical safe work practices that are necessary for their safety. Unqualified workers, such as painters or cleaners, occasionally come into contact with energized equipment, and therefore they must be trained to recognize and avoid electrical hazards.

Under OSHA’ 1910.147 (b) an Authorized Lockout Employee is a person who has completed the required hazardous energy control training and is authorized to lockout or tagout a specific machine or equipment to perform service or maintenance. A person must be certified as an Authorized Lockout/Tagout Employee in order to apply a lock or tag to control hazardous energy.

Authorized employee at UC Merced: A person who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance covered under this section.

All Authorized Lockout/Tagout Employees must be trained in:

- Core IIPP Safety Training;
- Electrical Safety/Lockout/Tagout Training for equipment he/she routinely works on; and
- Equipment specific procedures in their individual work units, if needed, on equipment not routinely worked on.

Concerning Electrical Safety, a “Qualified” person is an individual formally recognized as:

- Having completed required classroom training, and;
- Having sufficient understanding of a device, system, piece of equipment, or facility to be able to recognize and positively control any hazards it may present, and;
- Having completed site, area, facility, equipment and apparatus specific training, and;
- Possessing the work experience and formal training necessary to execute the work according to recognized and accepted technical standards, and;
- Demonstrated skills in procedures to protect against arc flash;
- Is usually a certified electrician but does not have to be if adequately trained; and
- Having authorization documented by their Supervisor and/or Project Manager.

A person can be “qualified” and then “authorized” to work on specific equipment, or in certain locations, or on certain projects but not the other way around.

General Guidelines for “Qualifying” Personnel

Qualification for electrical or electronics work is determined by the employee’s Supervisor or a Project Manager. It is based upon a risk review of known electrical hazards in the work place versus the known technical knowledge and safe-work expertise of the “qualified” worker.

A worker is determined “qualified” by the Project Manager or their Supervisor, when they can demonstrate adequate knowledge to work safely with electricity through a combination of classroom training (including required periodic retraining), formal electrical trade recognition, military, college or other training, work experience, and on-the-job training. Formal training can be the completion of apprenticeship, journeyman or comparable training. Experience may include formal technical related education courses and hands-on field or classroom lab work that may or may not result in licenses or certifications. In addition, any “Qualified Person” must have demonstrated skills to work on live equipment or on equipment that has potential for having residual electricity above 50 volts.

Specific “Qualifying Criteria”

EH&S is to use the following guidelines to determine whether an individual is “qualified” to perform specific electrical work. Different subsets of these criteria are selected according to the exact nature of the task; however, some analysis is always performed, no matter how minor the job. If the supervisor cannot verify a person’s qualifications, assistance from the Electrical Engineer or EH&S should be obtained. At a minimum, the documentation of an employee’s qualifications considers:

- The person’s ability to identify all possible hazards associated with a job task.
- The person’s ability to locate and read the appropriate engineering documents for the equipment or facility.
- The person’s knowledge of how to check calibration, condition, and operation of equipment or a facility.
- The person’s knowledge of how to shut down, isolate, and verify all sources of hazardous energy.
- The person’s awareness of UCM EI/LOTO requirements, and training in LOTO.
- The person’s ability to identify, interpret and implement all applicable codes and standards pertaining to a job task.

The person's experience and training to independently distinguish correct construction techniques from incorrect techniques.

- The person's experience and training to select the correct materials and components, and to use them in a manner consistent with their manufacture and/or listing.
- The person's ability to distinguish between appropriate and inappropriate equipment-grounding techniques.
- Demonstrated skills in procedures to prevent or protect against arc flash;
- The person's experience, training and ability to predict all likely failure modes of a particular construction, and to properly mitigate the effects of such failures.
- The person's familiarity with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, and insulated tools and test equipment.

If the person will be permitted to work within the Limited Approach Boundary of exposed energized parts operating at 50 volts or more, the person is at a minimum additionally trained in UCM's Electrical Live work Procedure as outlined in Appendix 1 of this program.

General Guidelines for “Authorizing” Personnel

Authorization to perform electrical or electronics work by a person at UCM is determined by their Supervisor and is based on the known ability of the person to safely perform specific tasks around specific known hazards at specific locations, or specific equipment, or on specific job sites

UCM Project Managers who engage the services of outside contractors who perform work on or near energized electrical components must assure these contractors are appropriately “qualified” before “authorizing” their work on specific projects.

Specific Authorizing Personnel Criteria

Only persons who are “Authorized” may conduct Electrical and/or Electronic work, or engage in Energy Isolation / Lock out-Tag out processes on UCM facilities / property. Training will include on-the-job orientation for specified equipment, types of equipment, or specific facility location(s) is documented to ensure that training is adequate and consistent for all personnel with similar tasks. This documentation is reviewed and approved by a person who is knowledgeable in safe electrical work practices and is familiar with the hazards involved in the work. This orientation / training covers:

- A detailed description of the scope of the work task being considered.
- The person's experience in the selection and use of test equipment for this task.
- Features and hazard review of the facility or equipment, including any specialized configuration.
- Relevant documents such as wiring diagrams, schematics, service manuals, and operating, testing, and calibration procedures.
- Location of all energy sources to, and within, the facility / equipment.
- Location of all energy-isolating devices.
- The system's energy control procedures, including energy-isolating devices, grounding and shorting procedures, and other energy-control procedures.

- The person's thorough familiarity with specific equipment-grounding requirements for this apparatus.
- Techniques, tools, and personal protective equipment (PPE) including arc-flash PPE used for the specific equipment / facility locations
- The person's knowledge of the nearest location of a telephone and how to alert emergency rescue personnel.
- If the person will be permitted to work within the Limited Approach Boundary of exposed energized parts operating at 50 volts or more, the person at a minimum additionally must be "qualified" and "authorized" to do the work at the specific location / job site according to UCM's Electrical Live work Procedure as outlined in Appendix 1 of this program.

Procurement of Contract Services for Electrical Work

UCM Project Managers who engage the services of outside electrical contractors must assure that such contractors are appropriately "Qualified" before "Authorizing" them to work on campus when seeking a Purchase Requisition for Contracted Services.

- Use suitably rated electrical tools and devices only as intended.
- Remove all jewelry before performing energized electrical work.
- Know how to shut down equipment in an emergency.
- Know UCM emergency procedures.
- Design and plan for safety.
- Reset a circuit breaker only one time for a given event and only after the cause has been identified and rectified.
- Maintain the protection of covers, barriers and shielding of all electrical equipment.
- Never drill into a wall or floor slab without approval of the Building Manager and Electrical Engineer.
- Never modify or penetrate premises wiring conduit or enclosed wire ways.
- Assure only qualified and authorized persons are allowed to work on premises wiring, conduits or enclosed wiring.
- If you must work "hot", always position yourself so you fall away from the equipment. If something goes wrong, you do not want a shock or arc to cause you to fall into any exposed wiring or bus. This simple work practice has saved many lives and prevented a lot of pain and misery. Remember, always make gravity your friend!

Energized "Live work" Electrical Work Requirements

It is UCM's policy to not issue live or energized parts except in extreme circumstances. This is the preferred method for protecting everyone from electrical hazards. Personnel must follow the UCM Energy Isolation – Lock out Tag out Program to safely de-energize live parts prior to working on them.

7. Training Requirements

Training requirements for personnel on the sections of this program that impact their work are noted below. Training is based upon hazard exposure assessment and may be delivered every three years up to annually as noted below by job activity, or in the “Training Qualifications” for personnel “qualified to work hot”. Training methods may include the online LMS, general safety training in offices, labs, shops and work environments, familiarization with UCM’s Energy Isolation / LOTO Program, specific training on the procedures outlined in this program, as well as work-site tail-gate meetings and safe-work planning efforts. Based upon the type of electrical work being considered, review the training requirements below to assure adequate training for you, your department and your co-workers.

All Staff and employee receive general electrical safety training as part of UCM orientation and general IIPP safety training on the roles and responsibilities outlined for everyone in this program. This includes review of Attachment O: Use of Extension Cords.

Trades Persons and others doing Electrical Work

On-going electrical and electronics training includes an annual review of this program and all appendices pertinent to the trainee’s work assignment as well as the campus EI/LOTO Program. Additional training may include tail-gate discussion of safe-work planning on the job-site based upon electrical work they will be doing in the hazard classes outline in (Attachment B), and required safe electrical work practices as outlined by (Attachment C), as well as the Hot-work Permit Procedure including Appendix 1, Attachments A – I, and any other pertinent training(s) identified by the employee’s Supervisor.

Supervisors

Supervisors have the same program information training that Trades Persons doing electrical work have. In addition, Supervisors who oversee electrical work receive more detailed training from EH&S on Electrical Hazard Identification and Control strategies, detailed knowledge of the procedures contained in this entire program document, documented education and on-the-job training, and may obtain professionally recognized credentialing. Supervisors also receive full training on of application of UCM’s Energy Isolation / LOTO Program and additional training as may be outlined by Supervision of work in the Hazard Classes noted in (Attachment C) as well as the Hot-work Permit Procedure including Appendix1 (Attachments A – I).

8. Record Keeping Requirements

Live work Permits, Shut Down Requests, Switch Logging, etc. documentation requirements are based upon Hazard Class determination (Attachment B), tracing of the individual project's hazard assessment using the Live work Flow Chart (Attachment A) and the process as outlined in (Appendix 1). Copies of a completed lock out tagout form will be given to EH&S and a copy will also be filed with Facilities POPD.

Supporting documentation, Purchase Orders, RFPs, etc. for Contracted Electrical Work are kept by the Supervisor / Project Manager for 7 years beyond the date of project completion, and must be made available for review to EH&S personnel upon request.

Approvals for Energized Electrical "Live work" (Briefings, Shut Down Requests, Electrical Live work Permits, Switching Procedures, and other Specific Procedures) are maintained by the supervisor of the person(s) performing the work for at least three years. Energized Electrical Work Approvals are made available to EH&S personnel upon request.

Training records, Tail-Gates and Work-site Orientations include the name and signature of the trainee, the date and content of the training, and evidence of successful comprehension, are kept

on file for a period in accordance with UCM records retention policies via the Learning Management System database. For training not documented by the LMS, records are kept by the Supervisor of the trainees performing the electrical work for 7-years beyond the date of project completion, and must be made available for review to EH&S personnel upon request.

Qualification Determination Records (e.g. resumes, job applications, military training records, on-the-job training records, etc.) are kept on file by hiring department's HR staff, with copies provided to Supervision as necessary, for the duration of the personnel's work-time at UCM, plus 7 years. Qualification records are renewed annually by the electrical worker's Supervisor by completion of Attachment D2 with copies filed in the electrical worker's personnel work file. Documentation must be made available for review to EH&S personnel upon request.

Authorization Records are kept on file by Project Supervision with copies provided to the Authorized Worker, for the duration of the personnel's work-time at UCM plus 7 years. Documentation must be made available for review to EH&S personnel upon request.

9. References

California Code of Regulations, Title 24, Part 3:
http://www.bsc.ca.gov/title_24/t24_2005_ccr.html

California Code of Regulations, Title 8, Subchapter 5, Electrical Safety Orders:
<http://www.dir.ca.gov/Title8/sub5.html>

UC Merced Energy Isolation and Lockout – Tag Out Program

NFPA 70e

Issued By and Next Review Date

This program is issued / adopted on in July of 2021 by Mal Donohue , Director, EH&S, UC Merced.

This program is reviewed and updated every 3 years or as recommended by the Electrical Safety Committee and determined necessary by the campus Electrical Engineer or EH&S Safety Engineer.

10. Appendix and Attachments

Attachment A: General Electrical Safe Work – Jobsite Procedures

All staff, project managers, contractors and employees with potential for exposure to electrical hazards must:

- Design and plan for safe work, identify hazards and anticipate problems.
- Resist “hurry-up” pressure and don’t hesitate to use the “Stop Work Policy” when hazards are identified.
- Know and apply the UCM EI/LOTO Program and Procedure.
- Whenever possible de-energize the equipment before testing.
- Positively ensure the correct circuit is identified before lockout and tagout.
- Always consider electrical equipment energized until positively proven otherwise.
- Assure the supervisor, or their designee, conducts a safe work briefing with all personnel in the area before commencing any energized electrical work.
- Use suitably rated electrical tools and devices only as intended.
- Remove all jewelry before performing energized electrical work.
- Know how to isolate all energy sources to equipment in an emergency.
- Know UCM emergency procedures for your work location.
- It is strongly recommended that a tripped circuit breaker only be reset by a “Qualified” person who has the demonstrated skills and knowledge to trouble-shoot, understand the cause, and safely re-energize the circuit. Report all tripped circuit breakers to Building Management, or to your Supervisor if you are doing the electrical work, regardless of cause or circumstances.
- Maintain the protection of covers, barriers and shielding of all electrical equipment.
- Be aware of hidden raceways and other utilities that may be concealed behind walls and/or concealed below or in concrete walls and slabs. Facility As-Built Drawing Reviews, Metal detectors, Proximity Detectors or X-ray methods must be employed prior to Saw Cutting or Core Drilling.
- Never penetrate premises wiring conduit or enclosed wire ways.
- If you must work “hot”, always position yourself so you fall away from the equipment. If something goes wrong, you do not want a shock or arc to cause you to fall into any exposed wiring or bus. This simple work practice has saved many lives and prevented a lot of pain and misery. Remember, always make gravity your friend!

Assure only qualified are allowed to work on premises wiring, conduits or related systems and equipment

Attachment A: Electrical two-Person Rules

Certain work requires two qualified persons. This is true if working on live electrical equipment or when open panel doors expose live electrical wiring.

When the "Two-Person Rule" is required, both workers must be present at the work site, both workers must plan ahead and be aware of the other worker's tasks, and both workers must:

1. Be a qualified person.
2. Be authorized to de-energize equipment by their Supervisor.
3. Know the location of nearest telephones, and how to alert emergency rescue personnel.
4. Be able to free an injured worker from the hazard without putting themselves at risk.
5. Be trained and current in cardiopulmonary resuscitation (CPR / AED).
6. Be trained and current in First Aid.
7. Remain in visual and audible contact with the workers performing the work and no more than 50 feet away at any time.

Under limited conditions, the Electrical Two-Person Rule may allow an exemption for a second person that is not a qualified person. To allow this exemption, all of the remaining requirements of the Two Person Rule above apply, and in addition the following must be met:

1. The Supervisor must approve this exemption.
2. During the briefing process the qualified person will assess the qualifications of the second person to determine that the work may proceed safely.
3. The second person must be trained and current in First Aid and CPR/AED.
4. The second person may not enter the Limited Approach boundary or the flash protection boundary.
5. The electrical disconnecting means must be located outside of the limited approach boundary and the flash protection boundary.
6. Both persons must be able to readily communicate with each other.
7. The electrical disconnect must be located within 50 feet and within sight of the second person.
8. The second person must be briefed in emergency procedures and the electrical work being performed.

Minimum Electrical Safety Equipment to have staged at the jobsite prior to starting work includes:

1. ABC Dry-type fire extinguisher
2. First Aid Kit
3. Insulation floor matt / blanket / arc shield (if necessary)
4. Required Personal Protective Equipment and insulated tools
5. Boundary Marking Tape
6. Communication means / radio / cell phone

Attachment B: Electrical Safety Watch Rules

A Safety Watch is a more stringent hazard control measure than the Two-Person Rule and is implemented when there are grave consequences from a failure to follow safe-work procedures. This occurs when work is considered high-hazard electrical work, as established by the Hazard Class, or by the work supervisor. When a Safety Watch is required, the Safety Watch is a qualified person who is responsible for monitoring the qualified person(s) doing the work. A Safety Watch must:

1. Be a qualified person
2. Have no other duties that preclude continually observing, coaching, and monitoring for potential hazards and mistakes
3. Have a thorough knowledge of the specific working procedures to be followed and the work to be done; and
4. Be close enough to the work in progress to safely monitor the progress and methods of the qualified person doing the work.
5. Use clothing and PPE appropriate to the hazard and the distance from the work in progress. In no case should the Safety Watch be more than 50 feet from the qualified person (s) performing the work.
6. Ensure only qualified persons are allowed to enter the Limited Approach Boundary.
7. Ensure that the Limited Approach Boundaries are properly barricaded and controlled.
8. If signs and barricades do not provide sufficient warning and protection for the Limited Approach Boundary, an attendant, (third person), shall be stationed to warn and prevent unqualified persons from entering.

Minimum Electrical Safety Equipment to have staged at the jobsite prior to starting work includes:

1. ABC Dry-type fire extinguisher
2. First Aid Kit
3. Insulation floor matt / blanket/ arc shield (if necessary)
4. Required Personal Protective Equipment and insulated tools
5. Boundary Marking Tape
6. Communication means / radio / cell phone

Attachment C: Electrical Hazard Classification and Requirements

Class	Criteria	Work Rules
A Low-Hazard Operation	<p align="center">Injury not likely.</p> <p align="center">Characterized by AC and/or DC Voltage less than or equal to 50 Volts</p> <p align="center">-----</p> <p align="center">For voltages greater than 50 volts but with less than 5mAmps available - See note 1 below.</p>	<p align="center">Follow basic office / lab electrical safety rules.</p>
B Medium-Hazard Operations	<p align="center">Potential for severe injury or death.</p> <p align="center">Characterized by voltage greater than a Class "A" hazard.</p> <p align="center">AC and DC Voltage from Greater than 50 to 250 volts.</p> <p align="center">-----</p> <p align="center">DC 50 Volts or less - See Note 2 below</p>	<p align="center">In addition to the above, follow the General Electrical Safe-work Rules.</p>
C Hazardous Operations	<p align="center">Potential for severe injury or death is greater.</p> <p align="center">Characterized by voltages greater than a Class "B" hazard.</p> <p align="center">AC and/or DC Voltage from Greater than 250 to 600 volts.</p> <p align="center">-----</p> <p align="center">DC 50 Volts or less, but 1000 - 10,000 Amps</p>	<p align="center">In addition to the above, apply the Two-Person Rule</p>
D High-Hazard Operations	<p align="center">Potential for severe injury or death is greatest.</p> <p align="center">Characterized by voltages greater than a Class "C" hazard.</p> <p align="center">AC and/or DC Voltage above 600 volts.</p> <p align="center">-----</p> <p align="center">DC 50 Volts or less, but Greater than 10,000 Amps</p>	<p align="center">Follow General Electrical Safe-work rules and implement "Safety Watch" for all "live work". (A total of 2 or more "Qualified Persons" at the work site is required.)</p>

NOTES:

1. All-voltage sources up to 20kV with available fault currents less than 5 mA are considered a Class "A" hazard.
2. DC power 50 volts or less, but with arc-flash potential of 5 mA - 1000 Amps has significant flash-burn / fire potential for direct short to ground (e.g. dropping a metal tool across battery-bank output terminals). Researchers, PIs, Project Managers or Supervisors are encouraged to apply Hazard Class B work rules / protection to such situations as a situation-specific hazard assessment may dictate.

Attachment D: Qualification Training Requirements

[Excludes research apparatus / instruments (such as an electrophoresis power supplies or a High-Pot Tester) that is approved by an NRTL as having safety-monitoring ground-fault circuit interruption built into the control circuit of the equipment / apparatus.]

Voltage / Amperage	Hazard Class	Training Required
Equal to or less than 50 Volts And 5 milli-Amps or less.	A Low-Hazard Operation	No Training Beyond General Employee Training
Greater than 50 to 250 Volts AC/DC and greater than 5 milli-Amps ----- Per Hazard Assessment - DC power 50 volts or less, but with arc-flash potential of 5 mA – 1000 Amps available	B Medium-Hazard Operations	Basic Electrical Safety Training including the General Electrical Safe- work Rules EI/LOTO Renewed every year First Aid and CPR Renewed every 3 years Arc Flash training with a requirement for demonstrated skills
Greater than 250 to 600 Volts AC/DC and Greater than 5 milli-Amps. ----- DC 50 Volts or less, but 1000 – 10,000 Amps available	C Hazardous Operations	Electrical Utilization Training First Aid and CPR Renewed every 3 years Arc Flash training with a requirement for demonstrated skills EI/LOTO
Greater than 600 Volts AC/DC ----- DC 50 Volts or less, but Greater than 10,000 Amps available	D High-Hazard Operations	Electrical Utilization Training High Voltage Training EI/LOTO First Aid and CPR Renewed every 3 years Arc Flash training with a

NOTE: Continued qualification training includes an annual review of this program and all appendices pertinent to the employee’s work assignment, electrical safe work program training pertinent to the employee’s work assignment as required by the above table, and any other training(s) identified by the employee’s Supervisor required for the safe performance of the employee’s duties. The Supervisor is responsible for identification and assurance of the resources necessary for the completion of training requirements for their individual direct reports. EHS ensures the necessary training is available through internal training or the identification of qualified outside training providers.

Attachment E: Project Documentation Requirements

Voltage / Amperage	Hazard Class	Documentation Required
Equal to or less than 50 Volts And 5 milli-Amps or less.	A Low-Hazard Operation	None
50 - 250 VAC/DC and greater than 5 milli-Amps	B Medium-Hazard Operations	Live work Permit and Generic Procedure
250 - 600 VAC/DC and Greater than 5 milli-Amps.	C Hazardous Operations	Live work Permit and Shut Down Procedure or Switching Log
600 VAC/DC and Above	D High-Hazard Operations	Live work Permit and Shut Down Procedure or Switching Log

Attachment F: Shock Protection Boundaries

All dimensions are distance from live part to personnel. Install construction cones and warning tape to define the “Limited Approach Boundary” on the work site. Make all “Qualified and Authorized” personnel on the job-site aware of the “Restricted Approach Boundary” distance for the work being completed.

Nominal System Voltage, Phase to Phase	Limited Approach Boundary (movable conductor)	Limited Approach Boundary (fixed conductor)	Restricted Approach Boundary	Prohibited Approach Boundary
<50	Not specified	Not specified	Not specified	Not specified
50 to 300	10 ft 0 in	3 ft 6 in	Avoid contact	Avoid contact
301 to 750	10 ft 0 in	3 ft 6 in	1 ft 0 in	0 ft 1 in
751 to 15kV	10 ft 0 in	5 ft 0 in	2 ft 2 in	0 ft 7 in
15.1 kV to 36 kV	10 ft 0 in	6 ft 0 in	2 ft 7 in	0 ft 10 in
36.1 kV to 46 kV	10 ft 0 in	8 ft 0 in	2 ft 9 in	1 ft 5 in
46.1 kV to 72.5 kV	10 ft 0 in	10 ft 0 in	3 ft 2 in	2 ft 1 in
72.6 kV to 121 kV	10 ft 8 in	10 ft 0 in	3 ft 3 in	2 ft 8 in
138 kV to 145 kV	11 ft 0 in	10 ft 0 in	3 ft 7 in	3 ft 1 in

INSTRUCTION NOTES ABOVE - From NFPA70E (2004) Table 130.2(C)

Attachment G: Flash Protection Boundary

For systems that are 600 volts or less, the Flash Protection Boundary shall be 4.0 feet based on the product of clearing times of 6 cycles (0.1 second) and the available bolted fault current of 50 kA or any combination not exceeding 300 kA cycles (5000 ampere seconds). For clearing times and bolted fault currents other than 300 cycles, or under engineering supervision, the Flash Protection Boundary shall alternatively be permitted to be calculated in accordance with the following general formula:

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

or

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

Where:

D_c = distance in feet from an arc source for a second-degree burn MVA_{bf} = bolted fault capacity available at point involved (in mega volt – amps)

MVA = capacity rating of transformer (mega volt-amps). For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by $1.25t$ = time of arc exposure (in seconds)

At voltage levels above 600 volts, the Flash Protection Boundary is the distance at which the incident energy equals 1.2 cal/cm^2 . For situations where fault clearing time is 0.1 second (or faster), the Flash Protection Boundary is the distance at which the incident energy level equals 1.5 cal/cm^2 .

NOTES:

From NFPA70E (2004) Section 130.3(A).

In lieu of analyzing the Flash Protection Boundary, Table NFPA70E (2004) 130.7(C)(9)(a) may be used.

Attachment H: Protective Clothing Characteristics

Unless actual arc-flash calculations are completed according to the most recent NFPA 70E Electrical Safety Code, and the available arc-flash energy is known for the work location is used to determine specific PPE and tools needed to work safely, either select PPE and tools per NFPA 70E Section 130.7, or select PPE and tools for the higher Hazard Class noted below.

NFPA70e Hazard Risk Category (Number) or Hazard Class (Voltage AC or DC)	Clothing System Description (No. of Layers) Special Tools / PPE	Cotton Fabric Total Weight (oz/yd ²)	Minimum Arc Rating ATPV or EBT cal/cm ²
0 A	Untreated Cotton (1)	4.5 - 7	N/A
1 A and/or B	FR Shirt and FR Pants (1) Use insulated tools.	4.5 - 8	4
2 B and/or C	Cotton Underwear plus FR Shirt and FR Pants (2) Use insulated gloves and tools	9 - 12	8
3 C and/or D	Cotton Underwear plus FR Shirt and FR Pants plus FR Coverall (3) Use voltage-rated insulated gloves and tools.	16 - 20	25
4 D	Cotton Underwear plus FR Shirt and FR Pants plus Double layer Switching Coat (4) Use voltage-rated insulated gloves and tools.	24 - 30	40

NOTES: Hazard Risk Category (Number) from NFPA70E (2004) Tables 130.7 (C)(9)(a) and 130.7(C)(11)

Hazard Class (letter) is a simple way to determine approximate hazard based upon available voltage of the exposed conductor being worked on. Hazard Risk Category (number) is based upon the available arc-flash amperes for approximately 6-cycles AC prior to circuit interrupters being tripped.