Electrical Safety Program

For more information about safety at work, visit: **ehs.berkeley.edu**

Berkeley Environment, Health & Safety

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Purpose

This program provides information about electrical hazards, guides University safe-work policy, electrical safety procedures, equipment design, development and installation for all electrical work, equipment and systems at UC Berkeley (UC Berkeley). 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 / research duties.
- Establishing training requirements for *qualifying* and *authorizing* persons who work on or near energized electrical circuits and components, and establishing *qualification requirements* for UC Berkeley-hired electrical contractors.
- 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 controlling energized electrical work through an assessment and documented *Energized Work Permit approval process* for **Energized Work Permit Program**.

Responsibilities

UC Berkeley management is responsible for providing employee safety training, conducting electrical safety inspections, correcting all electrical safety hazards, and ensuring that all new electrical equipment and components comply with codes and regulations.

Employees are responsible for the immediate reporting of electrical safety hazards, for not working on electrical equipment without proper training and authorization, and for inspecting equipment prior to using it.

Program Applicability

If you conduct, supervise or contract-hire:

Position	Applicability	Responsibility
Office Work	• Managing Extension Cords • Identifying electrical hazards in your area	• **Contact EH&S for guidance** • Conduct frequent inspections • Review **Electrical safety fact sheet** or see the **Identifying Electrical Hazards** section
Research / Experimental Design and Development	If you or your department conducts experimental design, equipment development, or connection to facility electrical distribution systems or other equipment that generates or in some way uses or stores electricity, whether AC or DC, then some portions of this program impact your work	• **Responsibility for Environment, Health and Safety** • Electrical Safety, Basic Training for Non-Electrical Workers, ILT • Electrical Safety in Labs- All Workers, ILT • **Workplace Safety** • **Labs and Research** • **Lab Equipment Electrical Safety Hazards & Controls** • **Contact EH&S** • **Contact Facilities to coordinate work** • **Shut down form**

Position	Applicability	Responsibility
Electrical workers	If you work with electricity, or equipment that uses electricity as a source of energy for operation, or equipment that generates electrical current during the course of your work at UC Berkeley.	You should be a **Qualified Person**: • A *qualified person* is one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.
Procurement	If you or your department procures electrical equipment or contract services then this program dictates the process to be followed to assure only electrically safe equipment and qualified contractors are brought onto UC Berkeley property, and that the installation of equipment, or a contractor's work, does not adversely impact the UC Berkeley electrical system or safety of the UC Berkeley community.	You need to order equipment that complies with the current list of **NRTLs — Nationally Recognized Testing Laboratory Program.**
Electrical Contractors	If you or your department hire contractors to do electrical work either on facilities and/or equipment owned / controlled by you or your department, then sections of this program dictate the necessary qualifications of the contractor for procuring their services, as well as processes and safe work practices to be followed for working and interfacing with the UC Berkeley electrical system, etc…	You should complete your **Qualified Person** training according to NFPA 70 E; 110.2 training requirements and **Attachment B** of this program.
Facility Design / Construction	If you or your department oversee the design / development / construction of new or refurbished facilities, then sections of this program impact the design work practices and the arc flash study specification to be included as part of your RFP / Bid process.	You should hire contractors that have completed **Qualified Person** training according to NFPA 70 E;110.2 training requirements and **Attachment B** of this program
All Faculty, Staff and Students	Identify electrical hazards and recognize they can **Safety Pause** and get adequate training and control to continue their work	• **Lab Equipment Electrical Safety Hazards & Controls** • Check **Attachment C** for required training. • Check **Attachment G** for use of extension cords. • Review **Electrical safety fact sheet** or see the **Identifying Electrical Hazards** section.

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; 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.

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

ESA: Electrical Safety Authority

ETL: Intertek Testing Services (formerly ETL Testing Laboratories)

FM: Factory Mutual

J: Joules (watt-seconds)

JHA: Job Hazard Analysis

mA: Milliamperes

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

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.

Definitions (continued)

Authorized Person - A qualified person delegated by their supervisor to perform specific duties under work hazard conditions known to that supervisor. An employee who is trained and authorized to perform work on electrical equipment and components, one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Conductive - Able to carry electric current.

Contractor - A general term used to define any outside individual, employer, business, or agency that is hired by UC Berkeley to conduct any type of electrical work on UC Berkeley facilities or equipment, or who conducts ancillary electrical work as part of fulfillment of a contract for any UC Berkeley 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 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 UC Berkeley 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) - Electrically connected to or having a source of voltage.

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

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.

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 **UC Berkeley LOTO procedures.**

Definitions (continued)

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 - 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 skills and knowledge related to the construction, installation, maintenance and operation of electrical equipment and installations appropriate to the hazard level of intended work, and has received safety training on the hazard controls involved in that work by their supervisor.

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 UC Berkeley, supervisors may include Principal Investigators (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.

Unqualified worker: An employee who has not been trained or authorized to perform electrical work.

Verified De-energized (see 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.

Definitions (continued)

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 *Energized 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.

UC Berkeley's Electrical Safe Work Policy

All researchers, PIs, staff, project managers, contractors and students ensure they and others around them are working in a safe manner. Please review **Safety Pause** in this program.

UC Berkeley 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. The **Campus Design Standards** have been updated and are now published. **Section 26** is dedicated to electrical guidelines in design.

- 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 **Energized Work Permit process**.
- Anyone at UC Berkeley who works on or near hazardous energized electrical circuits or components must be *qualified* and *authorized* 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) are 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 UC Berkeley design and engineering review as prescribed in the Attachment L of this program.
- All electrically energized equipment is used in a safe manner as intended by the manufacturer and within the equipment's **NRTL** listing.

Electrical Safe Work – Rules

All researchers, PIs, staff, project managers, contractors and students 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 **Safety Pause** when hazards are identified.
- Know and apply the **UC Berkeley 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 UC Berkeley emergency procedures for your work location.
- It is strongly recommended that a tripped circuit breaker only be reset by an *Authorized* and *Qualified* person who has the 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 on an *energized system*, 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 and authorized persons are allowed to work on premises wiring, conduits or related systems and equipment.
- Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed. Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by 1910.137.
- If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected. For example, an outer covering of leather is sometimes used for the protection of rubber insulating material.
- Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.
- Employees shall wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

Integrated Safety Management

The university prevents work-related injuries and illnesses through the **Integrated Safety Management (ISM)** approach to planning work activities as follows:

Defining the Work

Outline the scope of the work.

Analyze Hazards

Based on the scope of the work, hazards are identified and analyzed. A **Job Safety Analysis (JSA) online library** and **Safety Data Sheets (SDS)** are available to help with this process. Additional information on hazardous materials can also be found in the campus **Hazard Communication Plan** flip chart for shops and in the **Chemical Hygiene Plan** flip chart for each laboratory. The **Ergonomic Workstation Checklist** can be used to help analyze computer workstations. Off-site work hazards also need to be evaluated.

Develop Controls

Controls include administrative controls (such as procedures, signs, and training), engineered controls, and personal protective equipment. These controls are developed and implemented to address hazards in the workplace using a tiered approach. Low-hazard work or risks common to everyday life, such as routine office work or driving a university vehicle, may require only minimal planning to assure that standard work-related hazards are addressed (e.g., office ergonomics and safe driving practices). As the complexity of the operation and the associated hazard level increase, such as work in a shop or lab, the degree of planning increases. Waste products and streams (the route or process that products such as hazardous solids, liquids, and gaseous materials take on the way to eventual disposal) are anticipated and kept to a minimum. Plausible emergencies are considered and detailed planning may be necessary. Controls for off-site work hazards and plausible emergencies should be included.

Certain activities require advance authorization, consultation, and training before performing the work. See the EH&S website for a list of activities requiring **advance authorization**.

Implement the Work

Perform the planned work using the controls that have been identified.

Feedback and Improvement

Employees are expected to continually evaluate hazards and adjust the controls used to ensure that they continue to be effective. Safe work practices and behaviors are to be evaluated as a factor of an employee's performance. Lack of compliance with health and safety policies, procedures, and expectations may result in corrective action by the supervisor.

Analyze and Control Hazards

To assist with ISM process development, **ISM Standard Operating Procedure (SOP) templates** are available at the **EH&S website**.

Risk Assessment Procedure

The risk assessment procedure shall address employee exposure to electrical hazards and shall identify the process to be used by the employee before work is started to carry out the following:

1. Identify hazards
2. Assess risks
3. Implement risk control according to the hierarchy of risk control methods

Unsafe or unhealthy working conditions, practices or procedures will be corrected in a timely manner based on the severity of the hazards. Generally, supervisors are responsible for identification and correction of hazards that their employees face and should ensure that work areas they exercise control over are inspected periodically and/or at least annually.

Hierarchy of Risk Control Methods

The risk assessment procedure shall require that preventive and protective risk control methods be implemented in accordance with the following hierarchy:

(1) **Elimination**, (2) **Substitution**, (3) **Engineering controls**, (4) **Awareness**, (5) **Administrative controls**, and (6) **PPE**.

Safety Pause

All employees can request a safety pause to address a condition, behavior, or plan that they believe to be unsafe and that requires immediate action. This includes a situation where an employee has not received adequate instruction, personal protective equipment, and/or safety equipment. This allows employees to help prevent incidents and ensures that employees do not feel required to carry out tasks that they feel are unsafe.

A good faith request for a safety pause made under this program constitutes a *protected disclosure* under the **University of California Whistleblower Protection Policy**.

During a safety pause the following steps are taken:

1. **Request a safety pause** safely. Alert the person who is involved in or responsible for the perceived unsafe condition, behavior, or plan as soon as practicable.
2. **Respectfully explain** what is perceived as unsafe and express concern for the safety of the individuals involved.
3. **Pause the work** and attempt to resolve the alleged unsafe condition, behavior, or plan through discussion (and possible action) which should include the responsible person-in-charge, lead person, or supervisor. Resolution at the safety pause level includes an acknowledgment by the person who called for the safety pause that the situation is now acceptable as planned. The safety pause is concluded and the work may now proceed. If the person who called for the safety pause is not satisfied by the resolution, the matter will proceed to the escalation steps set forth below.

When a safety pause is called, it is the obligation of everyone associated with the work of concern to respect the safety pause and to participate in the resolution as appropriate. The involved parties may request assistance from EH&S at any point in the safety pause procedure for guidance on the interpretation and application of safety practices, laws, regulations, and codes.

Identify Electrical Hazards

Electrical current is measured in *amps* depending upon how much available current is present. The higher the current the higher the number of amps available to shock the body.

The table below shows the general relationship between the level of current exposure to a person and the reaction they may experience when current flows from one of their hands to a foot for just 1 second.
(Note: One *milli-amp* is 1/1000th of an amp.)

Reaction of the human body to electrical current	
Effect of AC current (95% of Young Adults Average weight 115-150 lbs)	
Perception Threshold - tingling sensation	0.7-1 mA
Slight Shock (not painful) - no loss of muscle control	1.2-1.8 mA
Shock (painful) - no loss of muscle control	6-9 mA
Shock (severe) - muscle control loss, breathing difficulty, onset of *let go* threshold	15-23 mA
Possible ventricular fibrillation - 3 send shock	0.1 A
Possible ventricular fibrillation - 1 send shock	0.2 A
Heart muscle activity ceases	0.5 A
Tissue and organ burn	1.5 A

Source: Electrical Safety in the Workplace by Ray and Jane Jones

Hazard Identification and Control

Hazard	Effect	Control
Electrical burns	Electric current flows through tissues or bone, generating heat that causes tissue damage	• **LOTO** • **Energized Work Permit** • Risk assessment • PPE • Inspections
Thermal burns	Injury to the different layers of the skin	• PPE • Administrative controls • Fire Life safety program

Hazard	Effect	Control
ARC flash **high-energy arcs and low-energy arcs**	Burns caused by arc flash are typically severe, 2nd-degree (partial thickness) or 3rd-degree (full thickness) burns. Clothing may catch on fire, and this will contribute to the area of the burn, further increasing the already high risk of mortality.	• **PPE for Arc flash** In new construction and renovation that alters electrical panels, distribution or switching equipment or other electrical infrastructure, Arc Flash studies are required. See **Division 26 00 00 *Electrical*** in the **Campus Design Standards** for detailed requirements.
Static electricity	Build up, explosion	Grounding

Protection Against Electrical Hazards

Insulation

Insulators such as glass, mica, rubber, or plastic used to coat metals and other conductors help stop or reduce the flow of electrical current. This helps prevent shock, fires, and short circuits.

Guarding

Inspect and enclose electric equipment to ensure that workers do not come in contact with any exposed electrical parts. OSHA requires that all high voltage tools and equipment is placed in an enclosed location, out of reach of other employees. Signs must alert about the electrical danger and forbid entry to unauthorized personnel.

Grounding

Grounding a tool, a piece of equipment, or a specific part of an electrical system means intentionally creating a low-resistance path that connects to the earth to prevent the buildup of voltages, including a static charge. Grounding is often a permanent part of any functioning electrical circuit. Grounding may also be added **temporarily** to electrical circuits or equipment by maintenance or research personnel to ensure safety and that the equipment they are working on cannot build-up an electrical charge greater than *ground*.

Electrical Protective Devices

Circuit protection devices, such as fuses and circuit breakers, automatically stop the flow of an electric current if a short circuit occurs. Fuses and circuit breakers protect the equipment by opening or breaking the circuit when too much current flows through them. OSHA requires construction sites and high-risk areas to use ground fault circuit interrupters.

Safe Work Practices

Employees can prevent electrical accidents by following OSHA safety instructions applicable to their workplaces. These may include de-energizing equipment before inspection or repair, keeping electrical tools in good working condition with timely maintenance, exercising caution when working near electrical lines, and always using appropriate protective equipment. Employees should receive appropriate training when working with electrical hazards. OSHA describes electrical safety-related work practice requirements in subpart S of 29 CFR part 1910.

- **Facilities Services Shutdown Process**
- **LOTO**
- **Energized Work Permit**

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:

- Lockout/Tagout Program and Procedure Audit

  De-energizing exposed electrical components is the preferred and primary method of electrical hazard control at UC Berkeley. The **UC Berkeley 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. Achieve an electrically safe work condition by following these six-step process:

  1. Determine all sources of energy by reviewing up-to-date drawings
  2. Disconnect all sources of energy by operating adequately rated disconnecting means
  3. Inspect, whereever possible, energy-isolating devices for visible breaks in power conductors.
  4. Perform a voltage test to determine the absence of voltage
  5. Install grounding devices, if determined to be necessary
  6. Install lock and tags
- 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.
- **Energized Work Permit**
- Rated insulated barrier mats, floor coverings or gratings to isolate the worker from conductive ground paths while working on exposed and energized electrical components
- All electrical distribution panels, breakers, disconnects, switches and junction boxes must be completely enclosed.
- Water-tight enclosures must be used if any of these components could possibly be exposed to moisture; · Structural barriers must be used to prevent accidental damage to electrical components.
- Conduits must be supported for their entire length, and non-electrical attachments to conduits are prohibited; non-rigid electrical cords must have strain relief wherever necessary.

Administrative Controls

The Electrical Safety Program requires persons who are both ***qualified*** and ***authorized***. A qualified and authorized person is an individual formally recognized as:

- One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk
- Having completed required classroom training
- 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
- Having completed site, area, facility, equipment and apparatus specific training, and processing the work experience and formal training necessary to execute the work according to recognized and accepted technical standards
- Having qualifications and authorization documented by their Supervisor and/or Project Manager.

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 UC Berkeley facilities or property.

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.

Persons may be qualified and then be authorized to work on certain equipment or projects in one work situation or location, but not authorized for another situation or location even though voltages and other electrical hazards and safe-work methods for both situations may be similar.

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 hazards in the workplace 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 formal electrical trade recognition, military, college or other training, work experience, and on-the-job training (including required periodic retraining).

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.

Specific Qualifying Criteria

Supervisors / Project Managers 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 PPCS Electrical Engineer, the Facility EH&S or UC Berkeley 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, refer to the **Hazard Control** Section of this program.

- 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 requirements of the UC Berkeley EH&S programs, 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.
- 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 needs to follow the **Energized Electrical Work Permit** process. The job briefing shall cover the job safety plan and the information on the energized electrical work permit, if a permit is required.

General Guidelines for Authorizing Personnel

Authorization to perform electrical or electronics work by a person at UC Berkeley is determined by their Supervisor in conjunction with the Project Manager, and is based on the known ability of the person to safely perform specific tasks around specific Known Hazards (like ARC flash) at specific locations, or specific equipment, or on specific job sites. In many situations, the Supervisor and the Project Manager may be the same person. But, in situations where they are two different people, a meeting to assess project hazards and needed qualifications to complete safe electrical work must be held between the Supervisor and the Project Manager before *authorizing* a *qualified* person to conduct electrical work on the Project Manager's project.

UC Berkeley 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 and authorized to work on specific projects (see **Attachment B**).

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 UC Berkeley facilities / property. Authorized Person(s) may develop location-specific safe-work procedures and conduct annual audits on existing procedures.

The Supervisor / Project Manager authorizes persons to perform work tasks only if they are satisfied that all relevant safe-work criteria are met concerning a specific job-site or location. 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 UC Berkeley's **Electrical Energized Work Permit** Procedure as outlined in program.

Unqualified Employees

Employees not qualified or authorized to perform work on electrical equipment and components will be trained in general electrical safety precautions for the purpose of hazard awareness.

The following electrical safety rules also apply to unqualified employees:

- Unqualified persons shall be trained in, and be familiar with, any electrical safety-related practices necessary for their safety
- Do not conduct any electrical repairs
- Report all electrical hazards to their supervisor
- Do not operate equipment if there is an electrical hazard
- Do not allow electrical equipment or components to contact water
- Remember that even low-voltage electricity can be physically harmful
- Do not use cords or plugs that are missing the 'ground' prong
- Do not overload electrical receptacles
- Only trained, authorized employees may repair or service electrical equipment
- Contractors must be licensed to perform electrical work
- Physical barriers must be used to prevent unauthorized persons from entering areas where new installation or repair of electrical components or equipment is being performed
- Only authorized employees may enter electrical distribution rooms
- All electrical control devices must be labeled properly
- Senior facility management must authorize any work on energized electrical circuits

General Protective Equipment and Tools

- When working near exposed energized conductors or circuit parts, each employee shall use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts. If the insulating capability of insulated tools or handling equipment is subject to damage, the insulating material shall be protected.
- Fuse handling equipment, insulated for the circuit voltage, shall be used to remove or install fuses when the fuse terminals are energized.
- Ropes and hand lines used near exposed energized parts shall be nonconductive.
- Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur. When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with the live parts.
- Alerting techniques. The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:
    - **Barricades** - Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.
    - **Attendants -** If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

Equipment Labeling

Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by **1910.145**.

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

- Nominal system voltage
- Arc flash boundary
- At least one of the following:
    - Available incident energy and the corresponding working distance, or the arc flash PPE category in **Attachment D** or Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) of NFPA 70 E for the equipment, but not both
    - Minimum arc rating of clothing
    - Site-specific level of PPE

Electrical Equipment Inspections

- Inspect all electrical equipment for hazards that could cause employee injury or death.
- Consider the following factors when determining the safety of the equipment:
  - Suitability for the intended use.
  - Proper insulation.
  - Heating effects under conditions of use.
  - Arcing effects.
  - Classification by type, size, voltage, current capacity and intended use.
- **Additional considerations**

Energized Work Issuance and Permit

According to NFPA 70 E, energized work is high risk and we should have a good reason to do the task energized (please refer to NFPA 130.2).

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

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

An energized electrical work permit shall be required and documented under the any of following conditions:

1. When work is performed within the restricted approach boundary.
2. When the employee interacts with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

Applicability

Who	What	Reference
UC Berkeley researchers	Cannot work on Hazard Class B, C or D*	**Attachment D**
UC Project Managers, UC Principal Investigators, and UC supervisors	Cannot work on Hazard Class B, C or D*	**Attachment D**
UC Berkeley Property Custodian	Identifies hazard class	**Attachment D** Must comply with ESP Must comply with **Campus Design** guidelines
*Consult **Hazard Classification and Risk Category** table below.		

UC Berkeley EH&S and other management may impose additional safety requirements on the work to ensure that the work is done safely and does not present an unexpected hazard to anyone as necessary. This may include providing additional safeguards such as **protective barriers**, **posting a UC Berkeley qualified person at the work site to control access**, or other safety measures as may be required to ensure safe working conditions for UC Berkeley personnel and contract workers.

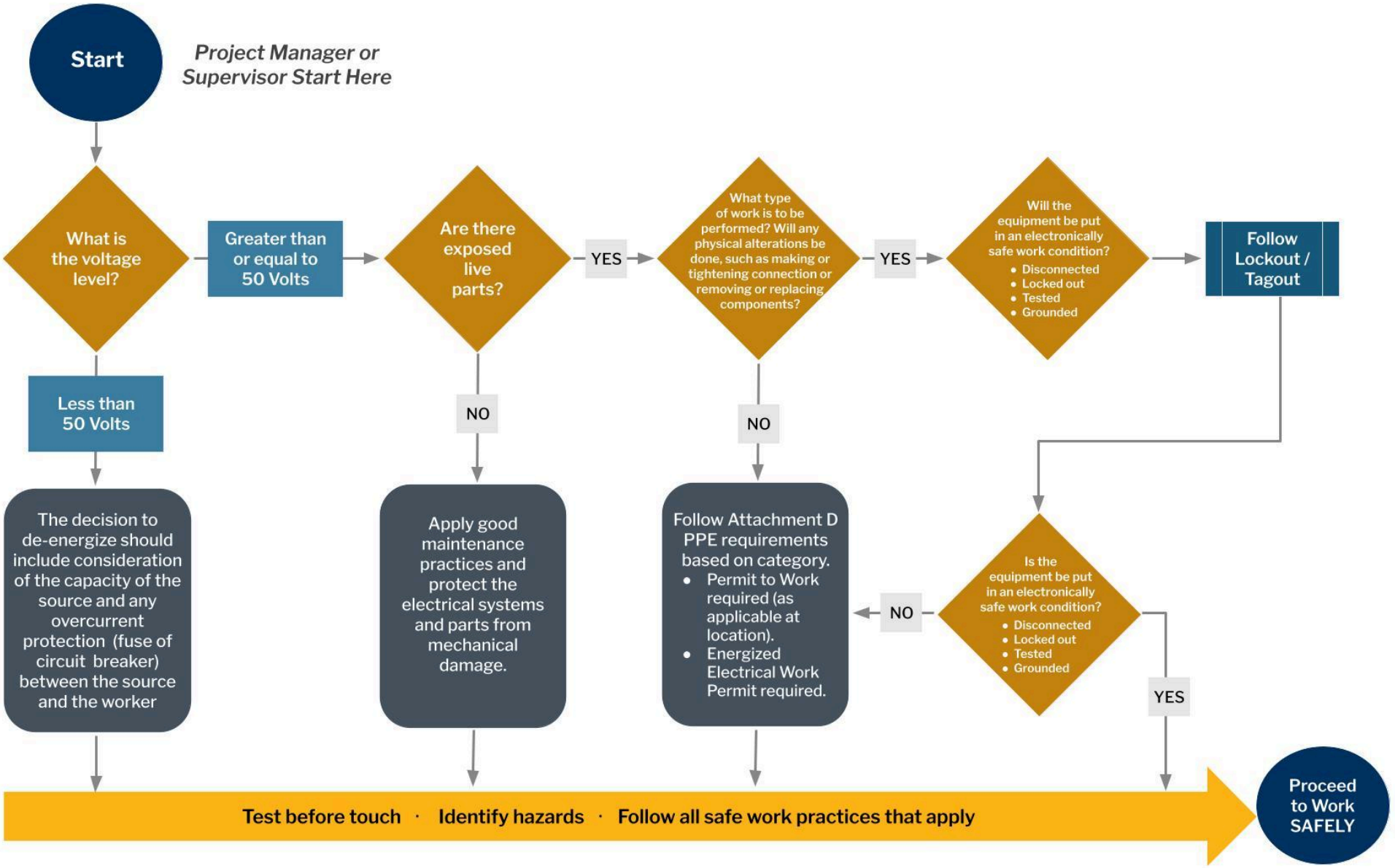
Energized Electrical Work Procedure

1. Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk. **Examples of additional hazards or increased risk include, but are not limited to:** interruption of life-support equipment, deactivation of emergency alarm systems, and shutdown of hazardous location ventilation equipment.
2. Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.
3. Determine if there is an option to de-energize and isolate the equipment per the **UC Berkeley Energy Isolation Program**. **Initiate FS Shutdown Request** or contact the Call Center at (510) 642-1032 to arrange safe de-energization of equipment.
4. Determine the Hazard Class of the task referencing **Hazard Classification** and Arc-Flash PPE Category in this document
5. Determine the Required Qualifications of personnel to perform the task referencing **Attachment B** (training).
6. If an Energized Work Permit is required:
   a. Identify and set up the **Shock Protection Boundaries**.
   b. Identify and set up the **Flash Protection Boundary**.
   c. Obtain the appropriate Tools and **wear the proper PPE**.
   d. Complete the **Energized Work Permit**.
   e. Obtain signature approval on the permit from Project Manager / Supervisor to proceed with the task.
7. If required by campus Electrical Engineer, Project Manager or Supervisor, develop a specific step-by-step shut down procedure and train all jobsite personnel on these procedures prior to commencing work.
8. Implement hazard control requirements and perform the Energized work task as outlined in the Energized Work permit and Switching Log procedure.

Hazard Classification and Risk Category

Voltage / Amperage	Hazard Class	Documentation Required	Work Rules
≤ 50 Volts and ≤5 milli-Amps	**A** Low-Hazard Operation	None	Follow basic office / lab electrical safety rules.
50 - 250V AC/DC and > 5 milli-Amps	**B** Medium-Hazard Operations	**Energized Work Permit** and Generic Procedure	In addition to the above, only a Qualified Person can approach and estimate this hazard
250 - 600V AC/DC and > 5 milli-Amps	**C** Hazardous Operations	**Energized Work Permit** and Shut Down Procedure or **Switching Log**	In addition to the above, apply the Two-Person Rule
> 600V AC/DC	**D** High-Hazard Operations	**Energized Work Permit** and Shut Down Procedure or **Switching Log**	Follow general **Electrical Safe Work Rules** and implement *Safety Watch* for all *Energized work* (A total of 2 or more **Qualified Persons** at the work site is required).

Energized Work Supervisory Flow Chart



Energized Electrical Work Permit

This permit Is **REQUIRED For testing above 600 V**. Specifically, *Breaker Replacement*, *Buss Modification*, *Hot Tap*, *Racking Out/In* or as deemed necessary. **For direct contact with 600 V & below energized parts ONLY.**

BUILDING		PNL		LOCATION	
DATE SUBMITTED		WORK DATE		FROM	AM/PM
CRAFT PERSON				TO	AM/PM
ASSISTANT (REQD)				W.O.#	
BUILDING CONTACT PERSON					

NOTE: The following should be completed by the electrically qualified persons doing the work

Description of Work to be Performed

Justification for Working with Energized Equipment

1	
2	
3	

Description of the Safe Work Practices to be Employed

JOB HAZARD ASSESSMENT

Results of the Shock Risk Assessment

1. Voltage to which personnel will be exposed
2. Limited approach boundary
3. Restricted approach boundary
4. Necessary shock, personal, and other protective equipment to safely perform the assigned task

Determine the Hazard class category

A	B	C	D
1	2	3	4

Refer to **Attachment A**, **Attachment D** for additional guidance

Refer to **Attachment C**, NFPA 70 E2018 Table 130.5(C)

Results of the Flash Risk Assessment

1. Available incident energy at the working distance or arc flash PPE category
2. Necessary are flash personal and other protective equipment to safely perform task
3. Are flash boundary

Refer to NFPA 70 E2018, Table 130.5(G), Table 130.7(C)(14), Table 130.7(C)(15)(a)

Arc-Flash PPE Categories for Alternating Current (ac) Systems

Emergency Phone #	**UCPD** (510) 642-6760	**TANG CENTER** (510) 642-2000

YOU ARE THE PERSON MOST RESPONSIBLE FOR YOUR SAFETY AND THE SAFETY OF OTHERS. PLEASE FOLLOW ALL POLICIES AND PROCEDURES.

Means employed to restrict access of unqualified persons from the work area	Table 130.7(C)(15)(b) Arc-Flash PPE Categories for Direct Current (DC) Systems

I agree the above described work can be done safely

Electrically Qualified Person		Date	
Supervisor		Date	
Employee		Date	

ATTACHMENTS

Attachment A - Electrical Hazard Classification

Class	Criteria
A Low- Hazard Operation	Injury not likely. Characterized by AC and/or DC voltage less than or equal to 50 volts --- For voltages greater than 50 volts but with less than 5 mA available All-voltage sources up to 20kV with available fault currents less than 5 mA are considered a **Class A** hazard
B Medium-Hazard Operations	Potential for severe injury or death. Characterized by voltage greater than a **Class A** hazard. --- AC and DC Voltage from Greater than 50 to 250 volts. 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.
C Hazardous Operations	Potential for severe injury or death is greater. Characterized by voltages greater than a **Class B** hazard. --- AC and/or DC voltage from greater than 250 to 600 volts. DC 50 volts or less, but 1000 – 10,000 Amps 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
D High- Hazard Operations	Potential for severe injury or death is greatest. AC and/or DC voltage above 600 volts. DC 50 volts or less, but greater than 10,000 Amps

Attachment B - 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.

Hazard Class	Voltage / Amperage	Training Required
A Low-Hazard Operation	Equal to or less than 50 Volts and 5 milli-Amps or less.	No training beyond general employee training
B Medium-Hazard Operations	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	Researchers, basic electrical safety training, including the general electrical safe-work rules For electricians, must be qualified person EI/LOTO renewed every year First Aid and CPR renewed every 3 years
C Hazardous Operations	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	For electricians, must be qualified person EI/LOTO renewed every year First Aid and CPR renewed every 3 years
D High Hazard Operation	Greater than 600 Volts AC/DC DC 50 Volts or less, but Greater than 10,000 Amps available	For electricians, must be qualified person EI/LOTO renewed every year First Aid and CPR renewed every 3 years

Attachment C - 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. Below tables are excerpts from NFPA 70 E, 2018.

Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
Nominal System Voltage Range, Phase to Phase[a]	Exposed Moveable Conductor[c]	Exposed Fixed Circuit Part	
<50V	Not Specified	Not Specified	Not Specified
50V-150V[d]	3.0m (10ft 0 in)	1.0m (3ft 6in)	Avoid Contact
151V-750V	3.0m (10ft 0 in)	1.0m (3ft 6in)	0.3m (1ft 0 in)
751V-15kV	3.0m (10ft 0 in)	1.5m (5ft 0in)	0.7m (2ft 2in)
15.1kV-36kV	3.0m (10ft 0 in)	1.8m (6ft 0in)	0.8m (2ft 9in)
36.1kV-46kV	3.0m (10ft 0 in)	2.5m (8ft 0in)	0.8m (2ft 9in)
46.1.kV-72.5kV	3.0m (10ft 0 in)	2.5m (8ft 0in)	1.0m (3ft 6in)
72.6kV-121kV	3.3m (10ft 8in)	2.5m (8ft 0in)	1.0m (3ft 6in)
138kV-145kV	3.4m (11ft 0 in)	3.0m (10ft 0 in)	1.2m (3ft 10in)
161kV-169kV	3.6m (11ft 8in)	3.6m (11ft 8in)	1.3m (4ft 3in)
230kV-242kV	4.0m (13ft 0in)	4.0m (13ft 0in)	1.7m (5ft 8in)
345kV-362kV	4.7m (15ft 4in)	4.7m (15ft 4in)	2.8m (9ft 2in)
500kV-550kV	5.8m (19ft 0in)	5.8m (19ft 0in)	3.6m (11ft 8in)
765kV-800kV	7.2m (23ft 9in)	7.2m (23ft 9in)	4.9m (15ft 11in)

(1) For arc flash boundary, see 130.5(A).

(2) All dimensions are distance from exposed energized electrical conductors or circuit part to employee.

[a] For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.

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

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

[d] This includes circuits where the exposure does not exceed 120 volts nominal.

Table 130.4(D)(b) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Direct-Current Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder
Nominal Potential Difference	Exposed Moveable Conductor*	Exposed Fixed Circuit Part	
<50V	Not Specified	Not Specified	Not Specified
50V-300V	3.0m (10ft 0 in)	1.0m (3ft 6in)	Avoid Contact
301V-1kV	3.0m (10ft 0 in)	1.0m (3ft 6in)	0.3m (1ft 0 in)
1.1kV-5kV	3.0m (10ft 0 in)	1.5m (5ft 0in)	0.5m (1ft 5in)
5kV-15kV	3.0m (10ft 0 in)	1.5m (5ft 0in)	0.7m (2ft 2in)
15.1kV-45kV	3.0m (10ft 0 in)	2.5m (8ft 0in)	0.8m (2ft 9in)
45.1.kV-75kV	3.0m (10ft 0 in)	2.5m (8ft 0in)	1.0m (3ft 6in)
75.1kV-150kV	3.3m (10ft 8in)	3.0m (10ft 0 in)	1.2m (3ft 10in)
150.1kV-250kV	3.6m (11ft 8in)	3.6m (11ft 8in)	1.6m (5ft 3in)
250.1kV-500kV	6.0m (20ft 0in)	6.0m (20ft 0in)	3.5m (11ft 6in)
500.1kV-800kV	8.0m (26ft 0in)	8.0m (26ft 0in)	5.0m (16ft 5in)

Note: All dimensions are distance from exposed energized electrical conductors or circuit parts to worker.

**Exposed Moveable Conductors* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

Attachment D - Personal Protective Equipment

PPE is the final layer of protective equipment, and the key term is *arc-rated* clothing. See the simplified table below from NFPA 70 E, 2018 Table H2

Clothing	Applicable Situations
Everyday Work Clothing Arc-rated long-sleeve shirt with arc-rated pants (minimum arc rating of 8) or Arc-rated coveralls (minimum arc rating of 8)	Situations where a risk assessment indicates that PPE is required and **arc flash PPE category 1 or 2b**
Arc Flash Suit A total clothing system consisting of arc-rated shirt and pants and/or arc-rated coveralls and/or arc flash coat and pants (clothing system minimum arc rating of 40)	Situations where a risk assessment indicates that PPE is required and **arc flash PPE category 3 or 4**

Notes:

Arc-Rated clothing is flame resistant but not all FR clothing are Arc-Rated.

The arc rating for a garment is expressed in cal/cm2.

OSHA's Electric Power Generation, Transmission, and Distribution Standard (1910.269) states that employees must ensure all workers who are exposed to electrical-arc or fire hazards do not wear clothing that could melt into their skin or ignite.

The estimated available fault current capacities and fault clearing times or arcing durations are listed in the text of Table 130.7(C)(15)(a) and Table 130.7(C)(15)(b). For power systems with greater than the estimated available fault current capacity or with longer than the assumed fault clearing times, Attachment D cannot be used and arc flash PPE must be determined and selected by means of an incident energy analysis in accordance with 130.5(G).

NFPA 70E Arc-Flash PPE Category Hazard Class (Voltage AC or DC)	PPE
1 A	Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm2 (16.75 J/cm2)[a]
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated face shield b or arc flash suit hood
	Arc-rated jacket, parka, rainwear, or hard hat liner **(AN)**
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles **(SR)**
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves[a]
	Leather footwear **(AN)**
2 B	Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm2 (33.5 J/cm2)[a]
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated flash suit hood or arc-rated face shield b and arc-rated balaclava
	Arc-rated jacket, parka, rainwear, or hard hat liner **(AN)**
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles **(SR)**
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves[d]
	Leather footwear
3 C	Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25cal/cm2 (104.7 J/cm2)[a]
	Arc-rated long-sleeve shirt **(AR)**
	Arc-rated pants **(AR)**
	Arc-rated coverall **(AR)**
	Arc-rated arc flash suit jacket **(AR)**
	Arc-rated arc flash suit pants **(AR)**
	Arc-rated arc flash suit hood
	Arc-rated gloves[d]
	Arc-rated jacket, parka, rainwear, or hard hat liner **(AN)**
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles **(SR)**
	Hearing protection (ear canal inserts)[c]
	Leather footwear

NFPA 70E Arc-Flash PPE Category Hazard Class (Voltage AC or DC)	PPE
4 D	Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40cal/cm2 (167.5 J/cm2)[a]
	Arc-rated long-sleeve shirt **(AR)**
	Arc-rated pants **(AR)**
	Arc-rated coverall **(AR)**
	Arc-rated arc flash suit jacket **(AR)**
	Arc-rated arc flash suit pants **(AR)**
	Arc-rated arc flash suit hood
	Arc-rated gloves[c]
	Arc-rated jacket, parka, rainwear, or hard hat liner **(AN)**
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles **(SR)**
	Hearing protection (ear canal inserts)[c]
	Leather footwear

Notes:

(AN): As Needed (optional), **(AR)**: As Required, **(SR)**: Selection Required.

[a] Arc-rating is defined in Article 100.

[b] Face shields are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or, alternatively, an arc-rated arc flash suit hood is required to be worn.

[c] Other types of hearing protection are permitted to be used in lieu of or in addition to ear canal inserts provided they are worn under an arc-rated arc flash suit hood.

[d] If rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.

Attachment E - Electrical Equipment Safe Work Space Requirements

Sufficient space is provided and maintained about electrical equipment to permit ready and safe operation and maintenance. Where energized parts are exposed, the minimum clear work space is never less than 6 ½ ft high (measured vertically from the floor) or less than 3 ft wide (measured parallel to the equipment). The depth is shown in the following table and in all cases the work space will permit at least a 90 degree opening of doors or hinged panels.

Condition 1 – exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed parts on both sides of the working space that are effectively guarded by insulating materials.

Condition 2 – exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls are considered as grounded.

Condition 3 – exposed live parts on both sides of the working space.

Nominal Voltage to Ground	Condition 1	Condition 2	Condition 3
601-2500 V	3 ft	4 ft	5 ft
2501 -9000 V	4 ft	5 ft	6 ft
9001 -25,000 V	5 ft	6 ft	9 ft
25,001 V – 75 kV	6 ft	8 ft	10 ft
Above 75 kV	8 ft	10 ft	12 ft

Notes: From the California Electrical Code (CEC2007), section 110.32.

Attachment F - Research Equipment Fabrication and Maintenance

Electrical Safety Authority (ESA). Each laboratory or R&D system application shall be permitted to assign an ESA to ensure the use of appropriate electrical safety-related work practices and controls. The ESA shall be permitted to be an electrical safety committee, engineer, or equivalent qualified individual. The ESA shall be permitted to delegate authority to an individual or organization within their control.

Responsibility The ESA shall act in a manner similar to an authority having jurisdiction for R&D electrical systems and electrical safe work practices.

Qualifications The ESA shall be competent in the following:

1. The requirements of this standard
2. Electrical system requirements applicable to the R&D laboratories
    - Design and construct equipment to protect personnel.
    - First-line and backup safeguards should be provided to prevent personnel from accessing energized circuits.
    - Establish periodic tests to verify that these protective systems are operative; like annual check of Estops
    - Design and construct equipment to protect personnel.
    - First-line and backup safeguards should be provided to prevent personnel from accessing energized circuits.
    - Establish periodic tests to verify that these protective systems are operative.

Designs

- Have designs reviewed: All systems and modifications to systems performing a safety function or controlling a potentially hazardous operation must be reviewed and approved at the level of project engineer or EH&S campus Safety Engineer.
- Have designs and operation verified: All systems performing safety functions or controlling a potentially hazardous operation must be validated by actual test procedures before being placed in service, at least once a year, and anytime the system is suspected of malfunction. Both the procedures and actual tests must be documented.
- The Department responsible for the equipment must maintain all documentation pertaining to the design safety features of the equipment, including any test data. This documentation must be available at any time to any safety inspector or EH&S Safety Engineer.
- Whenever possible, purchase **NRTL** approved equipment to conduct research instead of building your own. This equipment will be designed, tested and manufactured to generally assure safe work activities, and in most cases is designed with a failsafe.

Equipment Acceptability

Electrical equipment is considered safe only when it is used as specifically intended by its listing and design. Equipment listed by an **NRTL** must not be altered beyond the original design intent, and must not be used for any purpose other than that for which it was constructed. If equipment must be altered beyond the original design intent, please contact EH&S Safety Engineer to discuss hazard potential and hazard control options.

Any equipment that is being re-commissioned must be examined and/or tested, as appropriate, to verify the status of all safety features and the integrity of construction.

Electrical equipment, and electrical components used in experimental apparatus, should be listed or labeled by an **NRTL**.

EH&S may require that equipment that is not **NRTL**-listed undergo inspection and/or testing for conformance to standards. Such testing should be documented and submitted to EH&S for approval. The inspection record must specify, at minimum:

1. Equipment identification;
2. Evaluator name, date, mailstop, and extension;
3. Standard to which equipment is being evaluated;
4. Specific tests, results, and areas of examination;
5. Any conditions of product acceptability or limitations of use.
6. Inspection records are kept at the site of the apparatus with copies in the experimental records.

Equipment Safety Practices

Cable Clamping - A suitable mechanical-strain-relief device such as a cord grip, cable clamp, or plug must be used for any wire or cable penetrating an enclosure where external movement or force can exert stress on the internal connection.

Isolation - Isolate all sources of dangerous voltage and current with covers and enclosures. Access to lethal circuits (greater than 50V) must be either via screw-on panels (each containing no fewer than four screws or bolts) or via interlocked doors, panels, covers, etc. The frame or chassis of the conductive enclosure must be bonded to electrical ground with a conductor capable of handling any potential fault current. Access panels, doors, etc. that could allow contact with energized conductors should be interlocked with control circuits to de-energize electrical conductors if panel doors are opened / removed.

Lighting - Provide adequate lighting for easy visual inspection.

Disconnecting Means and Overload Protection - Provide overload protection and well-marked disconnects. Local *off* controls must be provided on remote-controlled equipment. Disconnects and breakers must be clearly labeled to identify the loads they control.

Power - All ac and dc power cabling to equipment not having a separate external ground but having line-to-line or line-to-ground voltage greater than 50V must have an equipment- grounding conductor unless cabling is inside an interlocked enclosure, rack, grounded wire way, or conduit, or feeds a commercial double-insulated or UL-listed ungrounded device. If the grounding of equipment introduces a greater hazard, the equipment must not be grounded.

Rating - Operate all conductors, switches, resistors, etc. within their design capabilities. Pulsed equipment must not exceed the average, the rms, or the peak rating of components. The equipment must be de-rated as necessary for the environment and the application of the components.

Safety Grounding of Capacitive Components - Use automatic-discharge devices on equipment with stored energy of 100J or more. Suitable and visible manual-grounding devices must also be provided to short-to-ground all dangerous equipment while work is being performed.

Electrical Equipment Rooms - Place an identifying label or sign on the door when equipment that may require servicing, manipulation, or inspection is concealed in an equipment closet or otherwise is obscured behind doors or panels.

Reuse of Circuit Breakers - Do not purchase used or reconditioned circuit breakers from vendors outside UC Berkeley. Reuse of UC Berkeley circuit breakers is permitted only after the circuit breaker has been tested by the UC Berkeley Electric Shop. Only use circuit breakers designed to be installed in specific distribution boxes per manufacturer model number.

Enclosures

The following specifications apply to circuits operating at greater than 50V, or storing more than 100J. An enclosure may be a room, a barricaded area, Faraday cage or an equipment cabinet:

Access - Interlock easily opened doors, hinged panels, etc. that allow ready access to exposed energized components so that the act of opening de-energizes the circuit. Automatic discharge of stored-energy devices must be provided.

Doors - Doors should be key-locked, and the same key should also be used for the locks in the control-circuit interlock chain, if applicable. This key must not be able to be removed from the door unless the door is closed and locked.

Heat - Mount heat-generating components, such as resistors, so that heat is safely dissipated and does not affect adjacent components.

Isolation - Ensure that the enclosure physically prevents contact with live circuits. The enclosure can be constructed of conductive or nonconductive material. If conductive, the material must be electrically bonded and connected to a good electrical ground. These connections must be adequate to carry all potential fault currents.

Seismic Safety - Secure all racks, cabinets, chassis, and auxiliary equipment against movement during earthquakes.

Strength - Ensure that enclosures are strong enough to contain flying debris caused by component failure.

Ventilation - Ensure that ventilation is adequate to prevent overheated equipment, and to purge toxic fumes produced by an equipment fault. Ventilation openings must not be obstructed.

Visibility - Ensure that enclosures large enough to be occupied by personnel allow exterior observation of equipment and personnel working inside the enclosure.

Cord and Plug Equipment (Testing and Maintenance)

An unqualified worker may remove covers and work on electrical equipment that has stored energy below 1000 joules and which is powered only through a 120 Volt Line-Cord that can be unplugged and positively controlled.

When electrical equipment has stored energy **above** 1000 joules and is only powered through a 120 Volt Line-Cord that can be unplugged and positively controlled then a qualified worker, wearing the PPE listed in **Attachment D**, must verify that all stored energy in the chassis has dissipated. Once the electrical safe condition is verified requirements for PPE and worker qualification are no longer in effect until the chassis is reenergized.

PPE requirements for verifying the safe state of 120 Volt cord and plug equipment, refer to **Attachment D**.

Attachment G - Guidelines for the Safe Use of Extension Cords:

Extension cords provide a convenient method of bringing AC power to a device that is not located near a power source. They are used as temporary power sources. They should not be stepped on, tripped over, stretched, cut, overloaded, and, in general, used improperly.

Relocatable Power Strips / Power Taps (for Office and Lab Bench Tops Only)

A relocatable power tap (also referred to as a *Power Strip*) is a variation of an extension cord, where the cord terminates in a row or grouping of receptacles. Relocatable power taps are commonly used in offices to provide multiple receptacles to office equipment. In general, all rules pertaining to extension cords also apply to relocatable power taps.

Acceptable Combination (for Office Only)

One single extension cord (single outlet) to a power strip (with over current protection) to a computer system is not recommended, but will be accepted to provide power to personal computer systems and peripherals only when there is no other reasonable way to do so. This is an interim solution, limited to 600 watts total load. For long-term installation a premises wiring outlet at the computer system will be required.

Additional Considerations

- Use only approved and properly maintained extension cords that have no exposed live parts, exposed ungrounded metal parts, damage, or splices.
- Use only heavy-duty or extra-heavy-duty rated cable.
- Use extension cords that are protected by a ground fault circuit interrupter (GFCI) around construction sites, in damp areas, or in an area where a person may be in direct contact with a solidly grounded conductive object (e.g. working in a vacuum tank). The GFCI can consist of a special circuit breaker, a GFCI outlet, or an extension cord with a built-in GFCI.
- Ensure that the extension cord is of sufficient current-carrying capacity to power the device. Use of an undersized cord results in an overheated cord and insufficient voltage delivered to the device, thus causing device or cord failure and a fire hazard. Undersized cords also constitute a serious shock hazard as it may not allow the breaker feeding it to trip.
- Always use three-conductor (grounded) extension cords, even if the device has a two-conductor cord. Never use two-conductor extension cords at the Laboratory.
- Extension cords are for temporary use: In general, roll-up the cord at the end of the day. If an extension cord is required for the same work at the same location on a continual basis, you should call Facilities to install an additional receptacle where you actually need the power, or move the equipment. Do not daisy-chain extension cords. Check the cord for damage each time you use it. Electricians can repair damaged cords.
- If extension cords cross foot-traffic aisles, use cord protectors of a bright color, preferably orange or yellow, to highlight the cord and protect it against impact. For very temporary installations, use brightly colored duct tape to tape the cord to the floor making sure the cord is straight without kinks or loops.
- If extension cords cross vehicle traffic aisles or roadways, use cord protectors strong enough to prevent vehicle contact with the cord.
- Do not use extension cords in place of permanent facility wiring.
- Avoid running extension cords through doors, ceilings, windows, or holes in the walls. If it is necessary to run a cord through a doorway for short term use, ensure that the cord is protected from damage and removed immediately when no longer in use. Make sure it is not a tripping hazard
- Relocatable power taps are not rated for heaters, refrigerators, toaster ovens, or other high power devices. They may be used only for office equipment such as computers, printers, etc.

- The total load on the relocatable power tap must not exceed 1440 watts or 12 amperes. Any single load (single receptacle) must not exceed 600 watts (5 amperes).
- Do not permanently mount relocatable power taps to any facility surface.
- Relocatable power taps are classified as temporary devices. It is acceptable to hang them from screws or hooks if they are manufactured with slots or keyholes.
- In equipment racks, the preferred method of supplying 120/208V utility power to rack-mounted instruments is via a special relocatable power tap specifically designed to be rack-installed.

Attachment H - Practices for Portable Workbenches

This section covers laboratory and shop workbenches that can be moved by sliding, rolling, etc. It does not cover built-in workbench assemblies that are permanently attached to structure surfaces. Such built-in assemblies must use appropriate fixed-wiring methods to provide power for receptacles, lighting fixtures, ventilation fans, etc, in accordance with the CEC.

Flexible cord and plug assemblies may be used to provide ac power to portable workbenches only when:

- The branch circuit voltage supplying the workbench is 150V or less.
- The overcurrent protection device rating on the branch circuit supplying the workbench is 20A or less.
- The flexible cord is no longer than 4.5 m (15 ft), is attached to the workbench with an approved tapered rubber-bushing cord-grip fitting, is no smaller than #14 AWG, is type-listed under the CEC as *Extra Hard Usage* (Type SO, G, W, etc.), is protected from physical damage, is routed to prevent tripping hazards, and is terminated in a listed attachment plug and mating receptacle interface that has the proper voltage and current rating for the branch circuit feeding the workbench.
- Each workbench has its own cord, attachment plug, and branch circuit receptacle. Workbenches must not be parallel fed or daisy chained by plugging their power cords into a receptacle located on another workbench.
- Each workbench wiring system has equipment-grounding protection that consists of a correctly sized and identified equipment-grounding conductor. This grounding conductor must be an integral part of the flexible cord. Grounding circuit continuity must be provided by the branch circuit wiring feeding the workbench, and at the interface between attachment plug and receptacle.
- All metal surfaces of the workbench assembly that are likely to become energized by an electrical fault are properly bonded to the equipment grounding conductor in accordance with the CEC.
- The number of workbench receptacle outlets is limited to no more than 10 duplex receptacles or 3 linear meters (10 linear ft) of wire-mold plug strip on a 15A branch circuit, or 13 duplex receptacles or 4 linear meters (13 linear ft) of an approved multi-outlet assembly on a 20A branch circuit. In any case, the continuous load fed by the workbench outlet receptacles must not exceed 80% of the rating of the branch circuit that feeds the workbench.
- Each workbench has proper seismic anchoring or other restraint against unintentional movement so that the cord-and-plug AC input power assembly is protected from damage resulting from tension, pinching, crushing, etc.
- If the bench is fitted with a metallic or otherwise conductive work surface, the workbench wiring system is protected by an approved GFCI.

Attachment I - Practices for Power Supplies

Primary Disconnect

Provide a lockable means of positively disconnecting the input on large power supplies. This disconnect must be clearly marked and accessible.

If provided with a built-in lock that is part of an interlock chain, the key must not be removable unless the switch or breaker is in the *off* position.

Overload Protection

Overload protection must be provided on the input and should be provided on the output.

Floating Power Supplies

Some research equipment (e.g. electrophoresis devices, x-ray tubes, ion-bombardment power supplies) employ ungrounded (floating) power supplies. This equipment may operate in voltages ranging from 50V to kilovolts, with output capacities in excess of 50mA, and must be considered a lethal electrical hazard. Users of such equipment must take special precautions to minimize electrical hazards. Follow all manufacturers' instructions for equipment use, testing, and training. The following general guidelines also apply:

- Locate equipment away from water and large metal areas.
- Do not use connectors and jack fittings that allow accidental skin contact with energized parts.
- Interlock readily accessible enclosures.
- Use nonmetallic secondary containment if liquids or gels are involved.
- Verify that the power supply is floating when commissioning and recommissioning the equipment and at least once a year.

Power Supplies used in Human Subjects Experiments

All research involving power supplies that supply power to research apparatus / equipment intimately in contact with human subjects must have fail-safe monitoring of output power circuits. Such power supplies must be able to detect any ground fault or phase-to-phase fault on the output of the power supply and immediately (within three-cycles) shut-down the output of the power supply to the research apparatus. Such power supplies must be manufactured, tested and approved by an **NRTL** to be *failsafe* for use on Human Subjects Experiments.

In addition, a second level of safety is required to physically isolate the Human Subject from any potential electrical hazard through use of dielectric shielding or containment of the research apparatus. Dielectric shielding must be reviewed and approved by an **NRTL** or a licensed Professional Engineer with expertise in the field of study prior to proceeding with Human Subject Experiments involving electrical apparatus.

Also, when power supplies are attached to building power, it's a good idea to power those using GFCI-protected power circuits.

Attachment J - Practices for Capacitor Hazards

This section describes some key practices for both high and low voltage capacitors. For further details the CEC and CalOSHA should be consulted.

Low voltage (<600v) Capacitor Safety Practices

- Capacitors containing more than 3 gallons of flammable liquid are enclosed in vaults or outdoor fenced enclosures.
- Capacitors are enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them.
- Capacitors are provided with a disconnecting and automatic means of draining the stored charge to 50 volts or less within one minute after the capacitor is disconnected from the source of supply.

High Voltage (>600v) Capacitor Safety Practices

- Capacitors shall be provided with a permanent nameplate giving the maker's name, rated voltage, frequency, kvar or amperes, number of phases, and the amount of liquid identified as flammable, if such is the case.
- Capacitors containing more than 3 gallons of flammable liquid are enclosed in vaults or outdoor fenced enclosures.
- Capacitors are enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them.
- Capacitors are provided with a disconnecting and automatic means of draining the stored charge to 50 volts or less within five minutes after the capacitor is disconnected from the source of supply.
- A means shall be provided to detect and interrupt fault current liable to cause dangerous pressure within an individual capacitor.
- Single pole individually operated or multiple pole group operated switches used for capacitor switching shall be capable of carrying continuously not less than 135 percent of the rated current of the capacitor installation.
- Care shall be exercised in handling and disposing of failed capacitors because of possible internal pressure and residual energy.

Storing capacitors - safety practices

- Capacitors shall be stored with permanent grounding straps attached to the capacitor terminals to prevent electrical charge build-up during storage.
- If you find an old capacitor that has been in storage but does not have a grounding strap attached to its terminals, do not touch the capacitor or try and ground it yourself. Contact the PP-CS Electrical Engineer immediately to determine next steps.

Attachment K - Practices for Inductor and Magnet Hazards

This section describes some hazards peculiar to inductors and magnets that can store more than 100J of energy or that operate at 50V or more. For further details the CEC and CalOSHA should be consulted, but consider that inductors and magnet hazards include:

- The ability of an inductor to release stored energy at a much higher voltage than used to charge it.
- Stray magnetic fields that attract magnetic materials.
- Time-varying stray fields that induce eddy currents in conductive material, thereby causing heating and mechanical stress.
- Time-varying magnetic fields that may induce unwanted voltages at inductor or magnet terminals.

Safety Practices

- **Energy Control** - Know and use the **UC Berkeley EI/LOTO** program and policies.
- **Automatic Discharge** - Use freewheeling diodes, varistors, thyrites, or other automatic shorting devices to provide a current path when excitation is interrupted.
- **Connections** - Pay particular attention to connections in the current path of inductive circuits. Poor connections may cause destructive arcing.
- **Cooling** - Many inductors and magnets are liquid-cooled. The unit should be protected by thermal interlocks on the outlet of each parallel coolant path, and a flow interlock should be included for each device.
- **Eddy Currents** - Units with pulsed or varying fields must have a minimum of eddy-current circuits. If large eddy-current circuits are unavoidable, they should be mechanically secure and able to safely dissipate any heat produced.
- **Grounding** - Ground the frames and cores of magnets, transformers, and inductors.

Rotating Electrical Machinery

Beware of the hazards of residual voltages that exist until rotating electrical equipment comes to a full stop. If needed block rotating electrical machinery so that mechanical rotation cannot occur prior to working on it.

Attachment L - Practices for Control and Instrumentation Design

Checkout

Check interlocks for proper operation after installation, after any modification, and during periodic routine testing. Document interlock tests in the experimental log book at least annually, whenever the apparatus has an unexpected event, or when the interlock system is modified.

Fail-safe design

Design all control circuits to be *fail-safe*. Starting with a breaker or fuse, the circuit should go through all the interlocks in series to momentary on-off switches that energize and *seal in* a control relay. Any open circuit or short circuit will de-energize the control circuit and must be reset by overt act.

Interlock Bypass Safeguards

Establish a systematic procedure for temporarily bypassing interlocks. Follow-up procedures should be included to ensure removal of the bypass as soon as possible. When many control-circuit points are available at one location, the bypassing should be made through the normally open contacts of relays provided for this purpose. In an emergency, these relays can be opened from a remote control area

Isolation

Isolate control power from higher-power circuits by transformers, contactors, or other means. Control power should be not more than 120V, ac or dc. All circuits should use the same phase or polarity so that no hazardous additive voltages are present between control circuits or in any interconnect system. Control-circuit currents should not exceed 5A.

Lockout

Use a keyed switch in interlock chains to provide positive control of circuit use. To ensure power removal before anyone enters the enclosure, this same key should also be used to gain access to the controlled equipment

Motor Control Circuits

Motor circuits must have a positive disconnect within view of the motor or, if this is not practical, a *disconnect* that can be locked open by the person working on these motor circuits.

Overvoltage Protection

Control and instrumentation circuits used with high-voltage equipment must have provision for shorting fault-induced high voltages to ground. High-voltage fuses with a high-current, low-voltage spark gap downstream from the high-voltage source are recommended. This also applies to all circuits penetrating high-voltage enclosures

Voltage Divider Protection

The output of voltage dividers used with high voltages must be protected from overvoltage-to-ground within the high-voltage area by spark gaps, neon bulbs, or other appropriate means.

Current Monitors

Measure currents with a shunt that has one side grounded, or with current transformers that must be either loaded or shorted at all times. Check instrumentation for function and calibration on a routine basis.

Attachment M - Switching Log Form

UC BERKELEY SWITCHING LOG						
Page ___ of ___		Planned Operations Date				
Purpose:						
STEP	**LOCATION**	**OPERATION**	**DEVICE**	**INSTRUCTIONS**	**TIME**	**COMP. BY:**
PREPARED BY			SCADA CHECK		DATE	
			HV CHECK		DATE	
DATE			ENG. CHECK		DATE	

Hard copies are maintained in a binder in the Electrician Supervisor office.

References

- **Electrical Safety - NIOSH**
- **Mining Topic - Electrical Safety - NIOSH**
- **1910.145 - Specifications for accident prevention signs and tags - OSHA**
- **Current List of NRTLs — Nationally Recognized Testing Laboratory Program**
- **California Code of Regulations, Title 8, Electrical Safety Orders**
- NFPA 70E, 2018 (see **Fact Sheet**)