

Chapter 8

ELECTRICAL SAFETY

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NOTE:

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 Denotes the beginning of changed text within a section.

 Denotes the end of changed text within a section.

8.1 Introduction

In the United States, 4,000 non-disabling and 3,600 disabling electrical contact injuries occur in the workplace annually. 2,000 workers are sent to burn centers with electric burns each year. Most of the burn victims become permanently disabled from their injuries. Typically, the victim's lives are forever restricted due to sensitivity to cold weather, mobility, or other physical barriers. Every day one person dies from electrical incidents.

This chapter contains general requirements and information for all electrical work at

LBNL. All employees of the lab, participating guests, students and all subcontractors working at the lab must comply with the requirements in this chapter.

8.2 Definitions and Acronyms

Definitions of terms used in this chapter are included as [Appendix D](#). Many terms used in this Chapter have meanings unique to electrical safety. All such terms will be printed in small capitals. Acronyms used are as follows:

AHD: Activity Hazard Document

AHJ: Authority Having Jurisdiction

ANSI: American National Standards Institute

BSO: Berkeley Site Office

DOE: Department of Energy

EEWP: Energized Electrical Work Permit

EH&S: Environment, Health & Safety

ESC: Electrical Safety Committee

J: Joules (watt-seconds)

LBNL: Lawrence Berkeley National Laboratory

JHQ: Job Hazards Questionnaire

LOTO: Lockout/Tagout

mA: Milliamperes

NEC: National Electrical Code. See also NFPA 70

NESC: National Electrical Safety Code

NFPA: National Fire Protection Association

NFPA 70: National Electrical Code. See also NEC

NFPA 70E: Standard For Electrical Safety in the Workplace

NRTL: Nationally Recognized Testing Laboratory

OSHA: Occupational Safety and Health Administration

PPE: Personal Protective Equipment

SAC: Safety Advisory Committee

V: Volts

W: Watts

8.3 Scope

The purpose of this chapter is to ensure the electrical safety of every employee, visiting guest and subcontractor at the lab by:

1. Defining safe work practices and use requirements for all people who work with electrically energized equipment as part of their normal job duties.

2. Establishing training requirements for qualifying and authorizing LBNL employees who work on or near energized electrical circuits and components.
3. Establishing a process for evaluating the electrical hazards of every energized electrical work task and for providing commensurate hazard controls.
4. Establishing a formal process for controlling energized electrical work through an approval process.

This Chapter applies to:

- The general LBNL population
- Contractors and subcontractors
- Facilities Electricians who work on or near electrical distribution and hard-wired equipment connections, and
- Researchers, students and participating guests who build, modify, test or repair electric or electronic equipment and apparatus, and
- Engineers, designers and technicians who design, build, modify or repair electric or electronic equipment and apparatus.

Reading this chapter does not qualify the reader to perform electrical work. Guidelines that are beyond the scope of this document must be established at each work area. They should include, as a minimum, the safety concerns outlined herein.

This chapter is in no way to be construed as a synopsis of all electrical requirements, nor as a substitute for formal study, training, and experience in electrical design, construction, and maintenance.

8.4 Policy

It is the policy of LBNL that:

1. LBNL shall comply with DOE and OSHA regulations, NFPA 70, National Electrical Code, NFPA 70E, Standard for Electrical Safety in the Workplace, ANSI C2, National Electrical Safety Code (NESCC), and other established safety standards to reduce or eliminate the dangers associated with the use of electrical energy.
2. All electrically energized equipment will be used in a safe manner as intended by the manufacturer and the NRTL listing or AHJ acceptance criteria.
3. All electrical wiring and equipment installations will comply with the National Electrical Code, OSHA regulations, and other consensus industry standards for electrical safety and engineering.
4. All employees have a responsibility to ensure they and others around them are working in a safe manner with the proper equipment and hazard controls. LBNL has a Stop Work Policy, (PUB 3000, Chapter 1.5) It is the responsibility of everyone to exercise this policy when observing unsafe work conditions or practices.
5. All research or test devices operating at a voltage greater than 50 volts with the ability to produce 5mA or more of current, or having capacitors greater than 1J (joules), or 1000 Joules if less than 50 volts, must be protected by an enclosure with secured or interlocked covers, or isolated in a manner that will prevent inadvertent contact with exposed live parts.
6. Fabrication of research and test equipment will be done following prescribed LBNL design and engineering requirements.
7. Any potentially electrically hazardous work will be performed following Lockout Tagout rules as described in PUB 3000, Ch. 18.
8. Work will only be performed on electrically-hazardous electrical circuits or components when it can be demonstrated that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Energized parts not considered electrically-hazardous shall not be required to be deenergized if there will be no increased exposure to electrical

burns or to explosion blast due to electric arcs. Approval is required per [Section 8.7.1](#) before approaching nearer than the limited approach boundary or arc flash protection boundary.

9. When work on electrically-hazardous electrical circuits or components is justified and approved, controls (guards, covers, shields, insulated tools & probes, remote methods) must be used to reduce the potential for contact with energized components.
10. All employees who work within the limited approach boundary or arc flash protection boundary of electrically-hazardous electrical circuits or components must be qualified and authorized by a JHA, AHD (See PUB3000, Chapter 6) or Subcontractor Electrical Safety Workbook (see [Appendix B](#)) prior to performing such work.
11. Safety related work practices and procedures for employees who work within the limited approach boundary or arc flash protection boundary of electrically-hazardous electrical circuits or components will be done in accordance with the requirements of NFPA 70E, Standard for Electrical Safety in the Workplace.
12. Subcontract employers will ensure their employees comply with NFPA 70 and NFPA 70E when their work is covered by the respective code or standard. LBNL points-of-contact for the contract will inform the contract employer of any additional information needed by the contract employer to perform an adequate electrical hazard analysis for their employees and ensure a Subcontractor Electrical Safety Workbook and if necessary, an Energized Electrical Work Permit (EEWP) is completed.

8.5 Electrical Hazards

8.5.1 Electrical Shock

Accidental contact with exposed electrical parts operating 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 deep internal burns, can occur even if the current does not pass through the vital organs or nerves.

8.5.2 Delayed Effects

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

8.5.3 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 to qualified workers are from arc-flash burns, not electrical shocks. Arc-flashes can and do kill at distances in excess of 10 ft. Equipment that presents an arc flash hazard must be marked with a label describing the available incident energy and level of PPE required for work within the arc flash boundary when the equipment is energized.

8.5.4 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 high blast pressure wave, high decibel levels of sound and high velocity shrapnel. Finally 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.

8.5.5 Other Burns

Other burns suffered in electrical accidents are of two basic types: electrical burns and thermal contact burns. In electrical burns, tissue damage (whether skin deep or deeper) occurs because the body is unable to dissipate the heat caused by the current flow. Typically, electrical burns are slow to heal. Thermal contact burns are those normally experienced from skin contact with the hot surfaces of overheated electric conductors.

8.6 Hazard Controls When Performing Electrical Work

The following hazard control hierarchy will be used to mitigate electrical hazards before approaching within the limited approach boundary or arc Flash protection boundary of energized electrical conductors or circuit parts:

1. Placing the electrically-hazardous conductors or circuit parts into an electrically safe work condition (see PUB 3000, Chapter 18, *Lockout/Tagout*).
2. Applying supplemental physical controls, such as panels, shields or barriers, to isolate employees from the energized components.
3. Administrative controls, such as the Energized Electrical Work Permit, assignment of a Safety Watch, and qualification training.
4. Personal protective equipment (PPE) to isolate workers from exposed hazardous electrical conductors or circuit parts.
5. Safe work practices (safe work rules & electrical safety considerations) to support the development of safe working habits.

8.6.1 Establishing an Electrically Safe Work Condition

Electrically-hazardous conductors or circuit parts are considered safe when the practices described in PUB-3000, Chapter 18, have been applied and verified using the following procedure:

1. Determine all possible sources of electrical supply to the specific equipment.
2. After properly interrupting the load current, open the disconnecting device(s) for each source.
3. Wherever possible, visually verify that all blades of the disconnecting devices are fully open.
4. Apply lockout/tagout devices in accordance with PUB3000, Chapter 18.
5. Use an appropriately rated voltage detector to test each phase conductor or circuit part both phase to phase and phase to ground to verify they are deenergized.
6. Where the possibility of induced or stored electrical energy exists, apply grounding devices.

8.6.2 Supplemental Physical Controls and Administrative Controls

Where it is infeasible or where a greater hazard would be introduced by de-energizing electrically-hazardous conductors or circuit parts, additional physical and administrative measures to protect the worker shall be incorporated into the work process. Examples to be considered include (but are not limited to):

- Energized Electrical Work Permit (See [Appendix A](#))
- Safe Work Practices and LBNL Electrical Safe Work Rules (see [Section 8.6.4](#))
- 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
- Rated non-conductive insulating shields or barriers for energized components that do not need to be exposed during the work
- Ground Fault Circuit Interrupters (GFCI's)
- Rated insulated barriers mats or gratings to isolate the worker from conductive ground paths while working on exposed and energized electrical components

- Rated insulated tools and test equipment

8.6.3 Personal Protective Equipment (PPE)

Qualified workers who are potentially exposed to electrical hazards that cannot be controlled through some engineering means must be provided with and use personal protective equipment that is appropriate for the specific work to be performed and the associated hazard level. NFPA 70E defines PPE requirements PPE is required for any work within the restricted approach boundary or arc flash protection boundary.

8.6.4 Safe Work Rules

Note: A summary of the LBNL electrical safe work rules is provided below. For a more thorough description of the safe work rules see [Appendix M](#).

1. Positively ensure the correct circuit is identified before lockout and tagout.
2. Whenever possible deenergize the equipment before testing.
3. The employee in charge must conduct a briefing before all energized electrical work.
4. Identify hazards and anticipate problems.
5. Resist "hurry-up" pressure.
6. Don't hesitate to use the Stop Work Policy (PUB 3000, Chapter 1.5).
7. Always consider electrical equipment energized until positively proven otherwise.
8. Use suitably rated electrical devices only as intended.
9. Remove all conductive jewelry before performing energized electrical work.
10. Know how to shut down equipment in an emergency.
11. Know LBNL emergency procedures.
12. Design for safety.
13. Reset circuit breakers only after the trip problem has been corrected.
14. Maintain the protection of covers, barriers and shielding.

15. Never drill into a wall or floor slab without Facilities approval. See Admin 053 Facilities penetration Policy.
16. Never modify or penetrate premises wiring conduit or enclosed wireways. Only qualified and authorized Facilities Department personnel are allowed to work on premises wiring, conduits or enclosed wiring. See [Section 8.8.4](#).

Note: For a listing and description of other electrical safety considerations, see [Section 8.13](#).

8.7 Energized Electrical Work Requirements

Energized electrical work is any activity inside the LIMITED APPROACH BOUNDARY or FLASH PROTECTION BOUNDARY of ELECTRICALLY-HAZARDOUS electrical conductors or circuit parts. Conductors or circuit parts are considered ELECTRICALLY-HAZARDOUS if they operate at a level that could cause injury to a worker through contact or exposure to an ARC FLASH HAZARD. Verification of absence of voltage for LOTO is considered to be energized electrical work. Authorization is required for all energized electrical work, but the method of authorization differs according to the task.

It is LBNL policy to deenergize electrically-hazardous parts, whenever possible, before an employee works on or near them (see PUB-3000, Chapter 18, *Lockout/Tagout*). This is the preferred method for protecting workers from electrical hazards. Workers are permitted to work on or near exposed energized electrical conductors or circuit parts only if it can be demonstrated that de-energizing would introduce additional or increased hazards or is infeasible due to equipment design or operational limitations. Energized parts that are not electrically-hazardous need not be deenergized if there will be no increased exposure to electrical burns or to explosion blast due to electric arcs.

8.7.1 Electrical Work Authorization

8.7.1.1 LBNL Employees

ATTENTION: THE REQUIREMENT FOR AN AHD OR EQUIVALENT AUTHORIZATION IS BEING PHASED IN FOR WORK WHERE THERE IS A HAZARDOUS ELECTRICAL EXPOSURE. LINE MANAGEMENT MUST INITIATE AN AHD OR EQUIVALENT BY APRIL 1, 2010, FOR ALL IDENTIFIED WORK HAVING SUCH EXPOSURES.

All inspection, testing, and troubleshooting of exposed electrically hazardous equipment, are authorized by an Activity Hazard Document (AHD) or approved equivalent. All other hazardous electrical work and exposures are authorized through an EEWP ([Appendix A](#)).

Any electrically hazardous work which is not specifically authorized in an AHD or approved equivalent, requires authorization through an EEWP ([Appendix A](#)). Whichever authorization method is used, approval always requires specific effective controls for both shock and arc flash hazards.

Electrical AHDs are initiated by accessing the AHD database, and selecting "Electrical" as a hazard. An electrical hazard schedule containing the hazards and controls to be described is provided in the AHD forms. Some elements of the electrical schedule may not apply to particular work operations. The Electrical Safety SME is available to assist in identifying type and severity of hazards, as well as developing appropriate controls.

Proposed methods of Electrical AHD equivalency are submitted to the Electrical Safety SME for review. If found acceptable, the equivalency is then forwarded to the EH&S Division Director for final approval. Once approved, the equivalent processes will be listed in Appendix R of this chapter.

All proposals shall include the following required elements:

1. Specific reasons that the AHD is not a feasible way of authorizing this work.

2. Identify the "Owner" (responsible individual) of the authorization process.
3. Names, titles, or job descriptions of persons who are to be authorized under this process.
4. The hazards analysis system (e.g. task hazard analysis) that will be used.
5. Means by which technical qualifications are established.
6. Description of circuit(s) and equipment to be worked on, including location.
7. Shock hazard analysis methodology.
8. Arc flash hazard analysis methodology.
9. Safe work practices to be employed.
10. Determination of shock protection boundaries.
11. Determination of arc flash protection boundary.
12. Description of the necessary personal protective equipment to safely perform the assigned task.
13. Means employed to restrict the access of unqualified persons from the work area.
14. Requirements to complete a job briefing, including a discussion of any job specific hazards.
15. Description of line management roles and responsibilities with respect to energized work authorization.
16. Method of auditing the equivalent process.

8.7.1.2 Subcontractors

LBNL Subcontractors performing any exposed electrically hazardous work shall complete a Subcontractor Electrical Safety Workbook ([Appendix B](#)) and an EEWP ([Appendix A](#))

8.7.2 Job Briefing

Before starting a task that might expose a worker to an electrical hazard, a person in charge shall brief the worker of the hazards involved, necessary PPE, work practices

required, and other information necessary to minimize the possibility of an electrical injury. The extent of the briefing depends on the risk and complexity of the task. If the work is authorized under an AHD the briefing will usually consist of simple direction by the supervisor noting any unique hazards associated with the assignment.

Work authorized by an EEWP requires a more extensive briefing (See [Appendix C](#) for a Job Briefing Checklist that can be used as an aid). The training and qualification currency of the worker should be verified and any potential emergency response actions discussed. Work should be released only when the supervisors and all workers know the scope of the work, hazards associated with the work, appropriate controls to manage the identified hazards and all are confident that the work can be done safely.

8.8 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.

A qualified and authorized person is an individual formally recognized by Laboratory Management as:

- Having completed the required LBNL 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
- Who have completed site, area, facility, equipment and apparatus specific training, and
- Who possesses the work experience and formal training necessary to execute the work according to recognized and accepted technical standards, and
- Whose qualifications are documented by his supervisor

A person can be considered qualified and authorized with respect to certain equipment

and methods but not authorized for others.

8.8.1 General Guidelines for Qualification

Qualification for electrical or electronics work is determined by the employee's Supervisor, and is based on a combination of LBNL classroom training (including required periodic retraining), formal electrical trade, military, college or other training, work experience, and on-the-job training. Formal training can be the completion of apprenticeship or comparable training. Experience may be a combination of, or include, formal technical related education courses, hand-on field or classroom lab work that may or may not result in licenses or certifications.

On-going electrical and electronics training must include an annual review of this Chapter and all Appendices pertinent to the employee's work assignment, Chapter 18 Lockout/Tagout, annual update of the employee's JHA and AHD(s) . For specific work requirements the supervisor may add classes to the employee's training course list not required by the JHA, but deemed important by the supervisor.

8.8.2 General Guidelines For Authorization

Authorization to perform electrical or electronics work by an employee is determined by the employee's Line Management and Supervision, and is based on the skills, knowledge, and ability of the employee to perform a specific task safely and correctly.

8.8.3 Specific Qualification And Authorization Criteria

8.8.3.1 On-The-Job Training

On-the-job training for specified equipment or classes of equipment must be documented to ensure that training is adequate and consistent for all employees with similar tasks. This documentation must be reviewed and approved by a person who is

knowledgeable in safe electrical work practices, and is familiar with the hazards involved in the apparatus. This training shall cover:

- Features of the equipment, including any specialized configuration
- Location of all energy sources to, and within, the equipment
- Location of all energy-isolating devices
- Techniques, tools, and personal protective equipment (PPE) including arc-flash PPE used for the specific equipment
- Relevant documents such as wiring diagrams, schematics, service manuals, and operating, testing, and calibration procedures
- The system's energy control procedures, including energy-isolating devices, grounding and shorting procedures, and other energy-control procedures
- Specific operations in which energized work is anticipated (if any), and the process to obtain authorization.

8.8.3.2 Task Specific Training Criteria

Supervisors shall use the following guidelines to determine whether an individual is qualified to perform specific electrical work. Different subsets of these criteria shall be selected according to the exact nature of the task; however, some analysis must always be performed, no matter how minor the job. Tasks that are performed less often than once per year shall require retraining before the performance of the work practices involved.

The supervisor shall authorize the employee to perform the work task only if he/she is satisfied that all relevant criteria are met. If the supervisor cannot verify an employee's qualifications, assistance from the Engineering Division or EH&S Electrical Safety Engineer should be obtained. As a minimum, the documentation of an employee's qualifications should consider:

- A description, in detail of the scope of the work task being considered.
- The employee's ability to identify all possible hazards associated with this task.
- The employee's experience in the selection and use of test equipment for this task.
- The individual's ability to locate and read the appropriate engineering documents for the equipment.
- The employee's knowledge of how to check the equipment calibration, condition, and operation.
- The employee's knowledge of how to shut down, isolate, and verify all sources of hazardous energy.
- The employee's awareness of LBNL LOTO requirements, and training in LOTO.
- The employee's ability to identify, interpret, and implement all applicable codes and standards pertaining to the task.
- The employee's experience and training to independently distinguish correct construction techniques from incorrect techniques.
- The employee'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 employee's ability to distinguish between appropriate and inappropriate equipment-grounding techniques.
- The employee's familiarity with specific equipment-grounding requirements for this apparatus.
- The employee's experience and training and ability to predict likely failure modes of a particular construction, and to properly mitigate the effects of such failures.
- The employee'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 (including instrument limitations).

- The employee's knowledge of the nearest location of a telephone and how to alert the lab's emergency rescue personnel.

If the individual will be permitted to work within the Limited Approach Boundary of exposed energized parts operating at 50 volts or more the individual shall at a minimum be additionally trained in all the following:

- The skills and techniques necessary to distinguish exposed energized parts from other parts of electrical equipment.
- The skills and techniques necessary to determine the nominal voltage of exposed energized parts.
- The approach distances specified in NFPA 70E and the corresponding voltages to which the qualified person will be exposed.
- The decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment (PPE) and job planning necessary to perform the task safely.

8.8.4 Electrical Distribution Systems (Premises Wiring)

Only qualified and authorized Facilities Department or approved subcontract personnel are allowed to perform electrical wiring or other work directly connected to any facility electrical distribution system (premises wiring as defined by the NEC). Premises wiring includes that portion of utilization equipment (see 8.8.5 below) that is permanently connected (hard-wired) to the facility electrical distribution system, viewed from the utilization equipment's first disconnect (or circuit breaker) looking backward into the premises wiring.

Connection to and diagnosis and repair of, circuit breakers in building electrical panels may only be done by specified qualified electrical workers.

If there is a question about what differentiates a facility system versus utilization equipment, consult the Electrical Safety Engineer or Facilities Electrical Shop Supervision.

8.8.5 Research Apparatus (Utilization Equipment)

Only qualified persons may fabricate, modify, install or repair electronic or electrical equipment used at LBNL. Supervisors are responsible for ensuring that only qualified persons under their supervision are assigned to work on electronic or electrical equipment at LBNL. The supervisor shall ensure the qualifications of these employees are documented. Any Laboratory worker or researcher who performs any electrical work must complete the EHS course *Basic Electrical Hazard Awareness* (EHS 260) as a prerequisite to further specific qualifications.

8.8.6 Electrical Two-Person Rule

Certain work requires two qualified persons. This occurs when work is considered electrically hazardous, as established by the conditions in [Appendix Q](#) or by the work supervisor. When the "Two-Person Rule" is required, both workers must be present at the work site, and each worker must be aware of the other worker's tasks and must:

- Be a qualified person.
- Be able to de-energize equipment.
- Know the location of nearest telephones, and how to alert emergency rescue personnel.
- Be able to free an injured worker from the hazard.
- Be trained and current in cardiopulmonary resuscitation (CPR).
- Be trained and current in First Aid.
- Remain in visual and audible contact with the workers performing the work.

Note: Both workers may perform separate work tasks so long as safety is not compromised.

8.8.6.1 Exemption To Two qualified persons

Under limited conditions, the Electrical Two-Person Rule may allow for a second person that is not a qualified person. All of the remaining requirements of Section 8.8.6 apply, and in addition the following must be met:

1. Management 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 First Aid and CPR trained.
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. The electrical disconnect must be located within 50 feet of the second person.
7. The second person must be briefed in emergency procedures and the electrical work being performed.

Note: This exemption only applies to the Two Person Rule, and shall not be used when a Safety Watch is required.

8.8.7 Electrical Safety Watch

A Safety Watch is a *more stringent* hazard control measure than the Two-Person Rule and must be 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 conditions in Appendix Q or by the work supervisor. When a Safety

Watch is required, the Safety Watch must be a qualified person who is responsible for monitoring the qualified person(s) doing the work. A Safety Watch must:

- Be a qualified person
- Have no other duties that preclude continually observing, coaching, and monitoring for potential hazards and mistakes
- Have a thorough knowledge of the specific working procedures to be followed and the work to be done; and
- Be close enough to the work in progress to safely monitor the progress and methods of the qualified person doing the work: the Safety Watch must 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.
- Ensure only qualified persons are allowed to enter the Limited Approach Boundary.
- Ensure that the Limited Approach Boundaries are properly barricaded and controlled. 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.

8.8.8 Service or Maintenance Contracts (Equipment Subcontractors)

Any subcontractor that will be performing work involving a potentially hazardous electrical exposure shall submit a Subcontractor Electrical Safety Workbook (Appendix B) for approval two weeks prior to beginning work at LBNL. In addition, the specific electrically exposed tasks shall be authorized with an EEWP.

8.9 Roles and Responsibilities

8.9.1 Authority Having Jurisdiction (AHJ)

ELECTRICAL SAFETY decisions are made by the Authority Having Jurisdiction (AHJ). NFPA 70 defines the AHJ as “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.” In an R&D environment, there are frequent situations where facilities, equipment and work practices are developed that are not adequately addressed by codes or standards and interpretations are necessary for work to proceed safely. DOE has granted electrical AHJ authority to the Laboratory Director, who has delegated this authority as follows:

Facilities and Premises Wiring

The AHJ responsibility for the infrastructure power distribution and premises wiring of the Laboratory is delegated to the Facilities Division Director. The AHJ for the facilities and premises wiring interprets the NEC (National Electrical Code, NFPA 70) and other codes and approves electrical construction, electrical installations, and installed facilities electrical equipment for Code compliance. The Facilities Division Director may appoint an appropriately qualified electrical engineer to execute this authority.

Research and Scientific Equipment

The Engineering Division Director is delegated the responsibility as AHJ to assure compliance with appropriate ELECTRICAL SAFETY requirements for the design, installation, maintenance, and repair of research and development (R&D) and scientific equipment and apparatus. The Engineering Division Director will appoint an Electrical Engineer, which will be delegated with this authority. The Engineering Director will apply criteria from ANSI, UL, NFPA and other standards as appropriate to establish the safety of equipment. LBNL specific criteria may also be developed based on established engineering principles.

Electrical Safety--Work Practices & Workplace Conditions

The Environment, Health and Safety Division Director is delegated the responsibility for

assuring compliance with all ELECTRICAL SAFETY requirements that pertain to maintaining safe electrical work practices and workplace conditions and thereby for protecting Laboratory employees, contractors and subcontract personnel from injury or death as a result of electrical hazards.

The AHJ for ELECTRICAL SAFETY is the Electrical Safety Engineer in the EH&S Division, or a qualified alternate designated by EH&S Management. The AHJ for ELECTRICAL SAFETY provides interpretations to ELECTRICAL SAFETY requirements in 29 CFR 1910 Subpart S and 29 CFR 1926 Subparts K and V, NFPA 70E, "Standard for Electrical Safety in the Workplace," and other standards and codes for worker electrical safety. The AHJ for Electrical Safety will additionally apply the requirements of NFPA 70 in evaluating workplace conditions. The AHJ for Electrical Safety is responsible for coordinating the electrical equipment acceptance process.

8.9.2 Appeals

All appeals regarding electrical and electrical safety questions must be submitted to the SAC via the Electrical Safety Committee. These groups review the appeal and make recommendations to the Deputy Laboratory Director for Operations for a final decision.

8.9.3 Responsibilities

8.9.3.1 Individual Employees

Individual Employees are responsible for their own and their coworkers' safety. Each employee will:

- Perform electrical work only when the electrical hazards are identified, known to the employee, adequately controlled, and when the employee is properly trained to perform the task.

- Stop any activity believed to be hazardous, using your STOP WORK AUTHORITY (PUB 3000, Chapter 1.5) if necessary. Everyone working at the lab has this authority and obligation to stop unsafe work.
- Attend training as required to achieve understanding of how to work safely and to respond to abnormal or emergency situations. No work requiring specialized training shall be performed by employees who are not current in their required training without Division and ESC approval.
- Notify a supervisor of any condition or behavior that poses a potential hazard.
- Wear and use appropriate personal protective equipment (PPE). Never perform any electrical work without the proper PPE.
- Immediately report any occupational injury or illness to the Medical Department and the appropriate supervisor. This will include any electrical shock, regardless of how minor the shock is perceived.

8.9.3.2 Supervisors

Supervisors of electrical workers have the primary responsibility of ensuring a safe working environment. They must;

- Assess the need for establishing, implementing, and maintaining procedures and/or work practices that will ensure the safe conduct of electrical work.
- Maintain a safe work environment and take corrective action on any potentially hazardous operation or condition.
- Ensure that approved, maintained, and tested personnel protective equipment and clothing is provided, available, and used properly.
- Assign only trained and qualified employees to electrical work and personally ensure that employees understand how to work safely by conducting a pre-job briefing as necessary.
- Ensure that shift routines, inspections, or surveillances that require working 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 appropriately.

8.9.3.3 Division Directors

Division Directors, by virtue of the delegation of responsibility for all aspects of occupational health and safety through line management, are responsible to the Laboratory Director for assuring compliance with all electrical safety requirements as defined in the procedure and pertaining to all programs, activities, and facilities within their respective divisions or areas of responsibility.

8.9.3.4 Facilities Division Director

The Facilities Division Director is responsible for interpretations of NFPA 70, The National Electrical Code. The Facilities Division Director will appoint a cognizant engineer, which will be delegated with this authority. This engineer will:

- Ensure the designs of electrical equipment installations are compliant with the requirements of this procedure.
- Provide testing and evaluation, as needed, for unique equipment.
- Provide shock hazard analysis and arc flash hazard analysis for electrical work as requested by organizations performing electrical work.

8.9.3.5 Engineering Division

The Engineering Division Director will nominate, from the Engineering Division, a chair for the Electrical Safety Committee. Engineering Division electrical engineers will:

- Under the direction of the Electrical Equipment Inspection Program manager,

provide for the testing and evaluations, as needed, of unique non-NRTL equipment.

- Provide shock hazard analysis and arc flash hazard analysis for electrical work activities as requested by organizations performing electrical R&D work.
- Ensure LBNL manufacturing, installation, testing and maintenance of R&D electrical equipment are compliant with electrical industry consensus standards.

8.9.3.6 Environment, Health and Safety Division Director

The Environment, Health and Safety Division Director is delegated the responsibility by the Deputy Laboratory Director for Operations for applying the Electrical Safety Program and assuring compliance with all electrical safety requirements that pertain to maintaining a safe working environment and protecting Laboratory employees and contract and subcontract personnel from injury or death as a result of electrical hazards.

The EH&S Division, is responsible for the documentation of Lab-wide electrical safety policies and procedures, site wide training, and field support for the implementation of the LBNL electrical safety program. EH&S will:

- Perform periodic assessments of electrical safety compliance at LBNL and provide feedback, incident reports and recommendations to the Electrical Safety Committee.
- Appoint a qualified Electrical Safety Engineer and an alternate.
- Maintain documentation of Lab-wide electrical policies and procedures.

As the authorized representative of the EH&S Director, the Electrical Safety Engineer has the responsibility to ensure the acceptability of experimental electrical wiring and apparatus. In this capacity the Electrical Safety Engineer will:

- Provide coordination for the LBNL electrical safety program, working in close cooperation with the LBNL Electrical Safety Committee of the Safety Review

Committee.

- Evaluate existing workplace safety by inspecting or assisting in the inspections of the workplace for National Electrical Code (NEC) and NFPA 70E compliance. The Electrical Safety Engineer shall have access and provide inspection services for all LBNL workplaces, including construction and leased operations.
- Serve as the primary reviewer for Energized Electrical Work Permits. These work permits require the approval of the Electrical Safety Engineer (or in his absence his alternate).
- Provide assistance to research divisions by evaluating the acceptability of experimental electrical wiring and apparatus. In this capacity, the Electrical Safety Engineer will, as needed:
 - Ensure electrical safety training course content complies with this Chapter, and ensure qualified trainers are available if needed. Develop and revise electrical safety training as necessary.
 - Review drawings, tests, and other documentation provided by the project engineers, principal investigators (PIs), or other responsible parties 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.
 - Inspect power systems and incidental wiring related to the experiment.
 - Conduct other inspections and analyses as necessary to verify the acceptability of the apparatus involved.
- Serve as the first contact AHJ within LBNL, which will provide formal interpretations of Fed OSHA electrical safety requirements and NFPA 70E, "Standard for Electrical Safety in the Workplace" and NFPA 70E.
- Assist the Facilities AHJ with interpretations of NFPA 70, National Electrical Code.
- Sits as an *ex officio* member of the Electrical Safety Committee and provide administrative and technical support as necessary and requested by the Chair to

ensure the effective operation of this Committee.

8.9.3.7 Electrical Safety Committee

The Electrical Safety Committee (ESC) is a subcommittee of the LBNL Safety Advisory Committee (SAC). The Electrical Safety Committee has the responsibility to develop and maintain the LBNL Electrical Safety Program. The ESC will:

- Provide the SAC with recommendations for training and requirements to implement the program.
- Provide the SAC with recommendations for funding of electrical safety initiatives.
- Develop and review technical material related to the electrical safety program.
- Maintain through review and revision, this Chapter and the technical electrical information in Chapter 18 Lock Out/Tag Out.
- Assist line management in the interpretations of electrical safety requirements.
- Assist in employee training and safety awareness for electrical hazards.
- Assess the performance of the Electrical Safety Program, including assessments, audits, inspections, and reviews of electrical accidents and near misses.
- The ESC may be requested to review electrical and electronic equipment and their installations at LBNL.

8.9.3.7.1 Composition

The ESC should be comprised of members who are knowledgeable in electrical safety, electrical systems, electrical equipment, and electrical requirements and standards (Fed OSHA, NFPA, NEC, and ANSI as appropriate).

8.10 Training

8.10.1 LBNL Training Courses

- LBNL course *Lockout /Tagout-OSHA* (EHS 256) is required for anyone who for any reason needs to remove shielding or barriers on electrically powered equipment.
- LBNL course *Adult Cardiopulmonary Resuscitation* (EHS 123) is required for all persons working in electrically hazard areas, and for persons serving as a Required Safety Watch.
- LBNL course *First Aid Safety* (EHS 116) is required for all persons working in electrically hazard areas, and for persons serving as a Required Safety Watch.
- Some level of electrical safety training such as EHS 260, EHS 249, and EHS 250 as determined by JHA and one's supervisor and ESC.
- Various levels of electrical safety training are offered by the Laboratory on an as-needed basis. Contact the LBNL Electrical Safety Engineer for classes or refresher training.

8.10.2 Training Matrix By Job Task

	LOTO – EHS 256	NFPA 70E – EHS 267 or EHS 268	First Aid Safety – EHS 116	Adult CPR – EHS 123	Basic Electrical Safety- EHS 260	Qualified Electronic Techs – EHS 249	Qualified Electrician – EHS 250
Facilities Electricians	X	X	X	X			X

HVAC, Plant Maintenance Technicians & Lighting Technicians	X	X	X	X	X		
Electronic Technicians	X	X	X	X		X	
Other General Lab Population performing authorized electrical work above 50V	X	X	X	X	X		

8.11 Recordkeeping

- Energized Electrical Work Approvals (Briefings, Permits, Switching Tag, Specific Procedures) shall be maintained by the supervisor of the person(s) performing the work for at least three years.
- Energized Electrical Work Approvals shall be made available to EH&S personnel.
- Training records shall be kept on file for a period in accordance with LBNL records retention policies.
- Qualification determination records (resumes, job applications, military training records, on-the-job training records, etc.) shall be kept on file for a period in accordance with LBNL records retention policies.

8.12 Standards

- 29 CFR Part 1910, *Occupational Safety and Health Standards*, Department of Labor
- 29 CFR Part 1926, *Safety and Health Regulations for Construction*, Department of Labor
- California Code of Regulations, Title 24, Part 3, *California Electrical Code*
- California Code of Regulations, Title 8
- NFPA 70, *National Electrical Code*
- NFPA 70E, *Standard for Electrical safety in the Workplace*
- NFPA 101, *Life Safety Code*

8.13 Electrical Safety Considerations

8.13.1 General Considerations

- **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.
- **Personal Protective Equipment (PPE):** Treat it well. Keep it clean and oil free. Perform an air leakage test of rated gloves before every use. Flame Retardant (FR) clothing requires special laundering to maintain its protection.
- **Joining a job in progress:** When you are assigned to a job in progress with lockout and tagout devices applied, you have an obligation to yourself to understand exactly what has been locked out and verified.
- **Practice proper housekeeping and cleanliness:** Poor housekeeping is a major factor in many accidents. A cluttered area is likely to be both unsafe and inefficient. Every employee is responsible for keeping a clean area, and every supervisor is responsible for ensuring that his or her areas of responsibility remain

clean

- **Maintain for safety:** Good maintenance is essential to safe operations. Establish maintenance procedures and schedules for servicing and maintaining equipment and facilities, including documentation of repairs, removals, replacements, and disposals.
- **Document your work:** An up-to-date set of documentation adequate for operation, maintenance, testing, and safety should be available to anyone working on potentially hazardous equipment. **Keep drawings and prints up to date:** Obsolete drawings should be marked as obsolete and if maintained, kept in a 'Dead File'. Be certain that active file drawings have the latest corrections. All facilities drawings are to be archived with the Facilities Records Analyst and Control Specialist.
- **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 above.
- **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.
- **Beware of wet areas:** While working with liquids (e.g., washing, mopping, and spraying), exercise extra care to avoid contact with electrical outlets or devices. Cover electrical openings if liquids can penetrate them. If the openings cannot be covered, the power must be disconnected and locked. (See Chapter 18, Lockout/Tagout.)
- **Choose safe test equipment:** The test equipment you use is considered personal protective equipment. (PPE). Each instrument will have the words "CAT I - 500V" (or the actual category and maximum working voltage) marked near the

input terminals. The CAT rating, I through IV, refers to the instrument's ability to withstand transient overvoltages. Since these transients attenuate as they travel through an electrical system, a higher CAT rated meter is required at the service entrance to a building, and decreasing CAT ratings are required the further one is from the entrance.

The categories and ratings for intended service are:

- Category I: Protected electronic equipment
- Category II: Appliances, portable tools, branch circuit receptacles
- Category III: Feeders, switchgear, large motors
- Category IV: Service entrance, metering, utility transformers.

Use only approved test leads to ensure the Category Rating the manufacturer has earned. Use of "after market" test probes and leads may void the Category Rating. If the test equipment is used for any kind of certification, it must be calibrated regularly, according to the manufacturers' maintenance instructions. This may vary from meter to meter, but generally, recalibration once a year is typical.

- **Keep manuals, read them:** Read the manuals before assembling or operating the equipment. These manuals are part of your safety system.
- **Set meter range switches before powering-up:** Decide in advance that you will not change ranges with a probe on a live test point. There are two reasons for this: First, remember, it's easy for a probe tip to slip off a live test point while you are looking at the range switch. Second, it may be possible to switch through a current measurement range effectively putting a dead short between the meter leads.
- **Drawings are safety equipment:** We have a special obligation to ensure all our

drawings and wire lists are accurate. We have to rely on engineering drawings and schematic diagrams of experimental equipment to identify sources of electrical power, diagnose operational problems, and begin logical troubleshooting. If the drawings are not truly "as built" (i.e., actually representative of the equipment we're asked to work on) we could be working in equipment with power present -- and not know it. When you discover a discrepancy between an engineering drawing and the actual equipment, stop and back out. If in your judgment it is safe to continue with the existing drawings under that judgment, do so with great caution, and on completion of the work mark-up the drawings with the corrections needed, and advise your supervisor.

- **Proximity sensors:** Proximity detectors may **NOT** be used in the final verification step for LOTO. Before probing a circuit with voltmeter leads (a direct contact), use every non-contact method at your disposal to check for zero-energy-state. You can almost always use a proximity sensor safely, before actual probing. Proximity sensors don't work on DC and, sometimes not on AC. They **CANNOT** guarantee that a circuit is in a zero-energy state, but they might disclose a source of AC power that is still energized and of which you were not aware. The rule-of-thumb is, if it indicates there is AC power present, believe it: if it indicates there is no AC power, further testing is necessary. As with your voltmeter, check the proximity sensor immediately before using it, then check is again, immediately after using it to ensure it is still actually working.
- **Keep proper spare fuses handy:** Check the manual for the proper fuse information. When replacing fuses, the replacement fuse must be an exact replacement. Using any other value or type fuse compromises the integrity and safety of the equipment.
- **Inspect your meter and meter leads for damage before each use.**
- **Beware UPS Systems:** Aside from internal battery voltages, Uninterruptible Power Sources (UPS's) are designed to provide 120-volt AC power to a computer or other critical equipment when its plug is removed from the wall receptacle. You

should expect to encounter 120-V AC when you open it.

- **Operating Circuit Breakers:** Circuit breakers may be used as switches under certain conditions. Use the following precautions when operating a circuit breaker for any reason.
 - Stand to the side of the distribution panel and look away when operating the handle. Avoid reaching across the panel to operate the circuit breakers.
 - Wear 100%, natural fiber (non-synthetic) shirt. This will reduce the potential of a burn should an arc occur.
 - Circuit breakers operating at 480 volts or more shall be operated only by qualified personnel.
- **Tripped Circuit Breakers:** Circuit breakers are designed to automatically shut off, or trip, when one of two conditions occur. The first is a defect in the circuit or equipment causing a short circuit or ground fault. Resetting a tripped circuit breaker into a short circuit or ground fault condition can be extremely hazardous. The second condition is an overload caused by too many electrical devices on the circuit. If it is obvious that the trip was caused by an overload condition, LBNL policy permits correcting the overload condition (i.e., unplug enough devices to adequately decrease the load) and resetting the circuit breaker one time, using the precautions described above. If the circuit breaker trips again, a qualified person must be notified to conduct an investigation before attempting to reset the circuit breaker.
 - Any circuit breaker condition not corrected as above shall be corrected only by a qualified person. Contact Facilities or Engineering for assistance.
- **Ground Fault Circuit Interrupter (GFCI):** GFCI's are devices designed to protect people from electrocution (death by electrical shock). They interrupt the circuit at extremely low current levels (4-6 mA). The NEC, OSHA, LBNL policy, and NFPA 70E require installation or use of GFCI devices under certain conditions. GFCI's will be installed to protect receptacles in: bathrooms, kitchen countertops,

rooftops, outside locations, vending machines, electric drinking fountains, and any 120 volt receptacle within 6 feet of sinks. GFCI protection for personnel shall be used when temporary wiring (e.g. extension cord sets) are used for activities such as: construction, remodeling, maintenance, repair, or demolition. Additionally, GFCI protection is required whenever personnel are working with electrical equipment in wet locations or using heater tapes. GFCI's should be considered whenever there is an increased risk of electrical shock.

GFCIs must be tested at least at 30-day intervals. Push the "test" button and observe if the "reset" button pops out and the receptacle turns off. Verify that the power is off by plugging in a small lamp or similar device. If this does not happen, the GFCI is not functional and must be replaced.

CAUTION: Testing of a GFCI will disconnect **all** receptacles protected by the GFCI. Before testing, determine which receptacles are protected. Verify that the interruption of power will not adversely affect other activities.

8.13.2 Clearance Around Electrical Equipment

Maintain access and working clearance space around power and lighting circuit breaker panels, motor controllers, and other electrical equipment in accordance with OSHA or the latest edition of the National Electrical Code (NEC), whichever is most stringent. For most equipment, this will be a space 30" wide by 36" deep.

Clearance space must not be used for storage or occupied by bookcases, desks, workbenches, or similar items. Not even a wastebasket.

8.13.3 Flexible Cords

Because cord and plug connections are generally well understood, this instruction does not cover portable hand-operated power tools, small kitchen appliances, office

equipment, electronic instruments, personal computers, and other similar equipment.

Allowed Uses: Flexible cords and cables may be used for:

1. Pendants.
2. Wiring of fixtures.
3. Connections of portable lamps or appliances.
4. Elevator cables.
5. Crane and hoist wiring.
6. Connecting stationary equipment that requires frequent interchange.
7. Preventing transmission of noise or vibration.
8. An appliance or equipment with fastenings and mechanical connections specifically designed to permit removal for maintenance and repair, and intended or identified for flexible cord connection.
9. Power cables (AC) for data-processing equipment.
10. Connecting moving parts.

When flexible cords and cables are used in conditions 3, 6, or 8, above, they must be equipped with an approved attachment plug and energized from a receptacle outlet.

Only qualified persons may install cord caps, (the attachment plug), on cords.

Flexible cord and cable, attachment plugs, and receptacles must be of the proper type, size, and voltage and current rating for the intended application.

Branch circuits that feed cord-and-plug connected equipment must be designed, have overcurrent protection and be grounded in accordance with the NEC.

All cord-and plug-connected equipment must be grounded with a correctly sized and identified equipment-grounding conductor that is an integral part of the ac power cord or

cable. Exception: Listed equipment that is protected by a double insulation system or its equivalent.

Forbidden Uses of Flexible Cables:

1. Substituted for the fixed wiring of a structure.
2. Run through holes in walls, ceilings, or floors.
3. Run through doorways, windows, or similar openings.
4. Attached to building surfaces.
5. Concealed behind building walls, ceilings, or floors.
6. Installed in electrical raceways, unless specifically allowed by NEC provisions covering electrical raceways.

Except for the temporary wiring provisions of NEC, the NEC does not allow the cord-and-plug connection of equipment to be energized from extension cords. Extension cords are not legal substitutes for the fixed wiring of a structure such as a receptacle outlet.

In industrial locations, a suitable guard or cover must protect the interface between attachment plug and receptacle from intrusion of process waste or other foreign material, such as cutting oils and machining chips.

8.13.4 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. Extension cords are probably involved in more electrical-code and safety violations than any other device at the Laboratory. They are stepped on, stretched, cut, overloaded, and, in general, used improperly.

Guidelines for the Safe Use of Extension Cords:

- 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.

Avoiding Misuse of Extension Cords: Observe the following restrictions to avoid misuse of extension cords:

- 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.
 - Removed immediately when no longer in use.
 - Not a tripping hazard.
- Do not daisy chain extension cords (i.e., plug one extension cord into another extension cord).

- Do not overload extension cords. Make sure that the wire size is sufficient for the current required.
- Do not cut off the ground pin of an extension cord or compromise the ground protection in any way.
- Do not use extension cords with a ground conductor that has less current-carrying capacity than the other conductors.
- Do not use frayed or damaged extension cords.
- Never splice extension cords, even for a repair. If an extension cord is damaged, it may be made into two cords, provided the proper connectors are used in a proper manner. Only qualified personnel may install cord caps for use with potentials greater than 50V.
- Only qualified personnel may make repairs of extension cords.

8.13.5 Relocatable Power Taps

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.

Additional considerations are:

- Only use NRTL (e.g. UL) labeled relocatable power taps.
- Refer to limitations of use marked on the data plate of the device. Do not exceed the load requirements of the device. Exceeding the load rating of the device could introduce a fire hazard.
- Do not permanently mount relocatable power taps to any facility surface. It is acceptable to hang them from screws or hooks if they are manufactured with slots or keyholes. It is acceptable to attach them with Velcro or any means that will not

require the use of a tool to remove.

- 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.
- Portable surge protectors manufactured before 1998 have been known to be a fire hazard and should be replaced when found.
- Relocatable power taps are not approved for construction sites or for outdoor use.

8.13.6 Heating Tapes and Cords

Many experiments at LBNL use heating tapes or cords, including many high vacuum apparatus. The heating tapes or cords pose an electrical shock hazard if not used properly. This advisory establishes requirements for the proper selection, care, and use of heating tapes and cords. These guidelines also apply to heating pads, wraps, or similar components intended to be applied directly to laboratory apparatus. Exemptions to the below requirements must be approved by the EH&S Electrical Safety Engineer.

This document supplements procedures and policies found in this PUB-3000 chapter (Chapter 8, Electrical Safety).

General Electrical Safety Requirements for Use of Heating Tape

- Whenever possible, use heating tapes that bear a Listing mark by UL or another Nationally Recognized Testing Laboratory (NRTL).
- Use three-wire (grounded) heating tape and cord systems whenever practical. Two-wire heat tapes and cords, while allowed for use at LBNL, are inherently less safe than three-wire systems.
- Inspect heating tapes and cords before use and discard any that display signs of excessive wear, fraying, or overheating. Do not repair damaged items.
- Properly ground all conductive equipment surfaces before heating tapes are

powered.

- Equipment undergoing heating with a variable AC transformer controlled heat tape must be monitored on a regular basis to prevent overheating of either the chamber or the heating device.
- Heating tapes and cords with an AC plug that can be split into two pieces must have the plug replaced or glued together.
- Read all of the manufacturer's instructions before using any heating device.
- Use heat tapes only on surfaces for which they are designed. Glas-Col® heating cords are an example of a cord that may not be used at LBNL for any purpose but heating glassware and non-metallic apparatus.
- If you are unsure whether or not your heating tape or cord is approved for use at LBNL, contact the EH&S Electrical Safety Engineer.

Heating Tape Power Source Requirements

- A Ground Fault Current Interrupter (GFCI) protected power source must be used. **Portable GFCI adaptors are acceptable.** Before use, the GFCI must be tested: depress the "TEST" button, verify that the "RESET" button pops out, and then depress the "RESET" button.
- A maximum of 1920 Watts of heating capacity may be placed on a 20-amp circuit breaker.
- A maximum of 1440 Watts heating capacity may be placed on any individual power cord, receptacle, or relocatable power tap (power strip).

Unusual Conditions

1. Circuit Breaker Trip

If a circuit breaker trips during a heating operation, this is usually because the circuit is overloaded. Disconnect an appropriate number of the heat tapes and

reset the breaker. If the breaker trips again, call an LBNL qualified electrical worker, Facilities Electrical shop (x6023) or the EH&S Electrical Safety Engineer (x4694) for help.

2. **GFCI Trip**

If a GFCI trips during the heating operation, it is permissible to reset the GFCI one time. Personnel must remain clear of equipment when the GFCI is reset. If the GFCI trips again, all of the heating tapes must be disconnected and thoroughly inspected for damage. If the problem persists, call an LBNL qualified electrical worker, Facilities Electrical Shop staff (x6023) or the EH&S Electrical Safety Engineer (x4694).

3. **Variable Transformer Issues**

If the fuse blows in the device, replace the blown fuse only with a fuse rated for the device. Using a higher current fuse than rated for the device will allow overheating and may cause a fire. Variable transformers and other control devices for heat tape control should be periodically checked by a qualified electrical worker for receptacle tension and proper fusing.

For more Information, please contact an LBNL qualified electrical worker, Facilities Electrical Shop staff (x6023), or the EH&S Electrical Safety Engineer (x4694) with any questions.

