Electrical Safety Management for Research Work Environments

1. Purpose / Background

**Purpose**: The purpose of this SOP is to describe requirements and procedures relative to hazards of electrical equipment and circuits to which MIT employees, students, affiliates, and staff (herein after referred to as “staff”) are exposed in the course of lab-based research. It provides guidance for program management of electrical hazards reasonably expected to be found in research-related working environments.

EHS and the MIT campus in general, have implemented an environment, health and safety management system (EHSMS) to address environmental and occupational safety risks. This SOP is part of a manual that forms the basis of the EHSMS. In order to ensure compliance with these requirements, EHSMS processes are expected to include this SOP as indicated, or as otherwise appropriate.

Requirements and procedures related to repair and maintenance related operations (such as MIT’s Dept. of Facilities or Capital Projects) are addressed in a separate EHS SOP (Electrical Safety Management for Facilities/Operations Work Environments).

**Background**: Electrical shock hazards are common in research laboratory settings and should be managed effectively through various measures. The MIT EHS department and the MIT campus have implemented an environment health and safety management system (EHSMS) to address environmental and occupational safety risks. This SOP is part of the manual that forms the basis for operations within the EHSMS.

In addition, OSHA regulates workplace electrical hazards as identified in the References section of this SOP. The consistent implementation of an electrical hazards risk and safety management policy is required and is the focus of this SOP.

2. Scope

This SOP primarily affects EHS functions such as program development, training development, and the EHSMS in order to manage conformance with requirements relative to MIT research-based activities where, in the course of routine or non-routine work staff can be reasonably expected to perform tasks (maintain, repair, test, or troubleshoot; herein after referred to as “work”) on or near exposed electrical equipment at greater than 50 volts AC, where conductive un-insulated or unshielded parts of the circuit are present.

In order to work on equipment as described above, staff must be Qualified as described in the Training portion of this SOP.

Research-related Departments, Labs, or Centers (DLCs) that directly hire outside contractors to maintain, repair, or troubleshoot electrical equipment, devices, or circuits are required to implement the Contractors Section of this SOP.
Laboratory design, redesign, or modification, requires the assistance of topic experts, e.g., regulatory, code enforcement, engineering, and others, to ensure that all appropriate electrical safety hazards and controls are identified, evaluated, and managed. Review or use of this SOP does not qualify an employee or student to work on electrical equipment.

For assistance, contact the EHS Office during the planning phase of a laboratory project.

3. Prerequisites
Generally, a EHS professional with adequate experience at MIT EHS and in relevant regulatory standards, industry standards, and electrical practices may implement and monitor the requirements of this SOP.

The MIT EHSMS includes the use of an on-line Training Needs Identification process via the MIT Learning Center. Completion of this assessment with respect to the relevant question on electrical hazards is required of all laboratory-based research staff. In turn, completion of the training indicated in the Training Needs Assessment and in Section 6.0 Training of this SOP is necessary to work on electrical equipment as described in Scope above.

4. Guidelines
Guidance and recommendations for basic good work practice can be found in the References section below.

5. Roles & Responsibilities

5.1. Departments, Laboratories and Centers shall:

5.1.1 Ensure that to the fullest extent possible, that all potentially affected staff complete the EHSMS Training Needs (TN) with respect to electrical hazards, and the corresponding training.

5.1.2 Ensure that contractors and Dept. of Facilities operations in their DLC are in conformance with the Section within for Contractor Electrical Safety Management and the EHS SOP for Electrical Safety Management Facility/Operations Work Environments.

5.1.3 DLC staff shall complete the TN and complete the respective training requirements, as described in the EHSMS

5.1.4 Supervisory staff such as Principal Investigators or their designees shall identify specific potential activities or staff assignments for emerging electrical hazard activities and ensure that staff complete the TN, as appropriate and described in the EHSMS

5.2. EHS Office shall:

5.2.1 Support or direct where requested, EHS Coordinators who work their research/lab groups with respect to electrical safety management. This would include issues regarding task and risk identification, training management, training delivery, and incident or accident investigation.

5.2.2 Maintain centralized training-completion records which are accessible to the EHS Coordinator.

5.2.3 Update and reissue this SOP as appropriate.

5.2.4 Periodically offer training classes for Basic Electrical Hazards and Safety for Laboratory/Research Personnel.
5.2.5 The EHS training coordinator will maintain and provide all relevant information from the training database with respect to status of training for DLCs or individuals.

5.3 Electrical Contractors Safety:

Electrical service, repair, and maintenance contractors shall provide the DLC that they are contracting with, evidence or assurance of the status of all employees, with respect to OSHA requirements for Qualified and Authorized staff.

Contractors shall ensure that employees assigned to work in DLCs have licensure issued by Massachusetts for electrical trades work, and sufficient job experience for the work under contract.

6. Training

MIT’s electrical training requirements apply to employees, students, and faculty who face a risk of electrical hazard that is not reduced to a safe level by the system or equipment itself. In other words, most equipment is expected to perform in a safe manner and not give electrical shocks or explode in an arc flash. Some equipment and scenarios, however, give rise to greater risk, such as when electricians open up panels or students work in research labs where unusual equipment is used. These employees must be trained to understand the specific hazards associated with electrical energy. They must be trained in safety-related work practices and procedural requirements, as necessary, to provide protection from the electrical hazards associated with their respective job or task assignments. They must be trained to identify and understand the relationship between electrical hazards and possible injury.

General electrical training is not adequate. Specific training must be provided to address the hazards encountered. For example, electricians who work in manholes must have training specific to the work done in the manholes, including rescue procedures and equipment. MIT lab personnel who participate in, or oversee electrical work in labs must receive training appropriate to the electrical hazards they will encounter, whether that includes high energy DC circuits or other unique electrical hazards. Training must match the hazards encountered, whether in the cogeneration plant, manholes and building substations, or in the lab. This training must be completed prior to beginning the work.

Affected research staff, as described in Scope and Prerequisites, must complete required training as selected through the EHSMS Training Needs process. The process is self-directed and individual Staff should select the class based on guidance provided in the on-line Assessment for training requirements and their individual work experience and knowledge. The Basic Electrical Hazards and Safety for Laboratory/Research Personnel would be required to complete as a one-time training session.

Upon successful completion of training, in the training as well as from skills and methods learned in professional practice, the staff member may perform work on electrical circuits, as defined in regulatory requirements. In addition, the staff member’s supervisor shall determine if relevant skills and knowledge are sufficient before allowing the staff member to do qualified work.

Only Qualified MIT staff may work on electrical equipment containing greater than 50 volts AC, wherever conductive parts of the circuit are exposed during work on or near the equipment. In order to become Qualified (See Section 10, Definitions) to work on or near live circuits between 50 volts and
400 volts, requirements for training within MITs EHSMS and described within this SOP, as well as sufficient practical work experience working with Qualified electrical staff must be completed.

Staff should contact the EHS Office or use the MIT Learning Center to register for training. Training is a one-time requirement and should be completed by new staff prior to assignment as described in Scope above.

High-voltage work (at greater than 400V) is not covered in this SOP or by this training.

7. Monitoring Requirements
The MIT EHSMS provides for routine and regular evaluation of training requirements and status, and gaps in completion. The EHSMS uses a database-driven training needs that requires new staff to register and complete training requirements, as determined through the assessment. EHS will periodically monitor overall compliance with the requirements for Training and report those to EHS Coordinators.

EHS Coordinators are expected to regularly monitor their DLC training databases to identify new or changed status conditions regarding affected staff. Wherever a DLC identifies significant issues related to incomplete training, they should make reasonable efforts to solicit completion of training.

The EHSMS provides for Consequences in circumstances of extended non-compliance with training requirements.

8. Record Management
This section incorporates record management practices defined by the EHS office or DLCs. These would include this SOP, the MIT Learning Center, training completion records and sign-in sheets, Level II EHSMS Inspection sheets, correspondence to affected or potentially affected or supervisors.

9. References
9.1 Standards
29 CFR 1910, Subpart S, "Electrical" Sections 301 through 335
29 CFR 1910.147: Control of Hazardous Energy (Lock-out, Tag-out)
DOE-HDBK-1092-98, Electrical Safety Handbook
NFPA 70, National Electrical Code
NFPA 70E, Electrical Safety Requirements for Employee Workplaces (latest edition)
NFPA 77, Recommended Practice on Static Electricity
Massachusetts Electrical Code, 527 CMR 12.00

9.2 Other SOP/ SOGs
• Electrical Safety Management for Facilities/Operations Work Environments, EHS-0059
• Guidelines for Use and Inspection of Extension Cords and Power Strips, EHS-0002

9.3 Supplementary Documents

An official hardcopy of this document exists in the EHS Office or on the EHS website. See Legal Disclaimer at: http://ehs.mit.edu/site/content/legal-disclaimer
Standard Electrical Safety Practices:
Observe the following practices when working with electricity or electrical equipment:

- Plug power equipment into wall receptacles with devices’ power switches in the off position.
- Unplug electrical equipment by grasping the plug and pulling. Do not use the cord to unplug equipment.
- Check the electrical outlet (receptacle) for missing or damaged parts, broken face plates or receptacle plastic, missing screws, loose plug tension, etc. If defective in any way, do not use and contact the customer service center at: 617-253-4948 or dof-csc@mit.edu. Their office is in Building 7-019. The Customer Service Center representatives will dispatch qualified electricians for service and to reset open (“tripped”) circuit breakers. Do not plug equipment into defective receptacles or attempt to reset open circuit breakers.
- Regularly evaluate wiring and equipment cords for fraying, cracking, or exposed inner wires (typically found where the cord and plug meet.)
- Check for damaged cord connections and defective cords clamps or grommets where the power cord enters the equipment or attach to the plug.
- Remove and discard: “cheater plugs” (devices that permit grounded, three-prong plugs to be inserted into two-prong receptacles); non-standard extension cords such as those with terminal junction box receptacles, or other jury-rigged equipment.
- Contact MIT’s customer service center at: 617-253-4948 or dof-csc@mit.edu. Circuit breaker or Ground Fault Circuit Interrupter (GFCI) unexpectedly trips, a wire or fuse box feels warm or a burning or electrical odor is noticed. These issues could indicate an electrical defect requiring repair to prevent hazard exposure, fire, etc.
- Recognize the difference between personnel and equipment protective devices. Over current protection devices, (e.g., circuit breakers, fuses, etc.), are designed to protect equipment and structures from fire, not people from electric shock. GFCIs are designed to protect people by detecting a ground fault and shutting down before an employee receives an electrical shock. See below.
- Ensure that high current demand electrical equipment such as toaster ovens, heaters, power tools, drive motors, etc. or other devices or appliances are grounded (three prong) or “double insulated” design.
- Identify the location and ensure accessibility to electrical circuit breaker panels, circuits and equipment disconnects controlling equipment, and work area lighting.
- Maintain a 36” clearance around all electrical panels or permanent electrical equipment installations.
- Ensure power cords are not draped over hot pipes, radiators, or sharp objects.
• Treat all exposed conductors, even when "de-energized", as if they are live until they are confirmed to be locked and tagged out-of-service. Never remove a lock or tag.
• Clearly identify emergency shut off and disconnects.
• Use the right length, size (gauge) and type (service rating) of cord to prevent wiring overload. Refer to manufacturers limitations of use and determine current load that devices will create. Use circuits, cords, and outlets within capacity and use limitations.
• Use GFCI's where/when appropriate; See below.
• Never insert objects, (e.g., pencils, fingers, metal tools, paper clips, conductive debris, etc.) into receptacles or unused conduit openings in junction or circuit breaker boxes.
• Tag defective electrical equipment with a “do not operate” tag, remove from service, and either discard or provide to a qualified and authorized electrical repair person for maintenance, repair, or disposal.

Emergency Assistance, Response, and Rescue: Consider the following action in the event of an employee contact with live electrical current:
• Shut off the electrical current if the victim is still in contact with the energized circuit.
• Call or have someone else call for Police, Fire, or Emergency Medical Services (EMS). If another person calls for EMS, have them return to verify that the call and contact was made.
• If you are unable to reach the main circuit switchgear (circuit breakers) quickly, pry the victim from the circuit with a non conductive object such as dry wood or plastic. Never touch or contact the victim.
• Stay with the victim until emergency medical responders arrive. Do not leave the victim unless there is no other option.
• Once you know that the victim is no longer energized, call to the victim to see if s/he is conscious. If conscious, reassure them and tell the victim not to move. Quickly examine the victim for signs of:

Unconscious: If the victim is unconscious, check for signs of breathing. While you do this, move the victim as little as possible. If the victim is not breathing, someone trained in CPR should begin artificial rescue breathing, and check to see if the victim has a pulse. Quick action is essential! To be effective, CPR must be performed within 4 minutes.

Bleeding: If there is major bleeding, place a cloth over the wound and apply pressure. If the wound is in an arm or leg and continues bleeding, gently elevate the injured area while keeping pressure on the wound. Keep the victim warm and talk to him or her until EMS arrives.

Ground Fault Circuit Interrupters (GFCI):
GFCIs are designed to protect people from serious injury or death. A GFCI is a fast-acting device that detects a difference in current between two circuit conductors. If either conductor contacts an unintended electrical path (a situation known as a ground fault), the GFCI opens the circuit in a fraction of a second. Should a difference as small as 4 to 6 mA be detected, the GFCI is tripped and the current is shut off.
GFCI's are usually in the form of a duplex receptacle. They are also available in portable and plug-in designs and as circuit breakers that protect an entire branch circuit. GFCI's can operate on both two- and three-wire ground systems. For a GFCI to work properly, the neutral conductor (white wire) must (1) be continuous, (2) have low resistance, and (3) have sufficient current-carrying capacity which is generally the case with a good condition circuit and outlet.

GFCI's help protect from electrical shock by continuously monitoring the circuit. However, a GFCI does not protect from line-to-line hazards such as simultaneously touching two "hot" wires (240 volts) or touching a "hot" and neutral wire simultaneously.

The National Electric Code (NEC) requires that GFCI's be used in the following:

- Receptacles located within 6 feet of a sink.
- Receptacles installed outdoors.
- Electrical use near water.
- Electrical equipment user is grounded (by touching grounded material).

**Functional Testing**: Test GFCI's regularly by pressing the "test" button. If the circuit does not trip, the GFCI is faulty and must be replaced. Tag the receptacle and contact DOF.

Indicate locations or equipment where GFCI are required by MIT but may not be appropriate, e.g., receptacles dedicated to refrigerators or other heavy equipment.

**Extension Cords and Power Strips**: See Guideline for Use and Inspection of Extension Cords and Power Strips, EHS-0002.

**Electrical Equipment Clearance**: Maintain a minimum working clearance of 36 inches on each side of electrical enclosures, e.g., circuit breaker boxes, electrical panels, etc. Working clearance may not be less than 30 inches wide in front of the covered electric equipment/enclosures.

**Supplemental language**: The space in front of electrical enclosures may not be used for storage. This access and working space shall be kept clear at all times for operation and maintenance personnel and may not be used for intermittent/incidental storage of nonpermanent equipment or furniture, which could interfere with ready access to the electric equipment in the event of an emergency.)

10. Definitions

"Authorized": Trained by MIT’s EHS Office on electrical safety principles and practices and control of hazardous energy methods and techniques, and authorized by MIT’s Electrical Services (Department of Facilities) and EHS Office to perform lock-out/tag-out and electrical installation, modification, repair, replacement, or rehabilitation.

"Qualified Person": A qualified person (QP) must having training on and knowledge of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. A qualified
person must also be familiar with the proper use of the special precautionary techniques; personal protective equipment including arc flash protective clothing; insulating and shielding materials; and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others. MIT’s broad range of electrical systems on campus and in labs makes this a helpful distinction. Supervisors/PI’s need not be overly concerned that the training be extensive, as long as it addresses the hazards that the employee or student will encounter.

“Work on or near exposed electrical conductors”: Working in proximity to circuits or parts of circuits which, in a manner during the work task in question is not protected by normal configuration or insulation of the electrical parts or circuit. Work that involves tools or techniques that intentionally or otherwise could be reasonable expected to contact potentially conductive parts of the circuit are affected. This would include painting near circuit or circuit parts where normal coverings are removed or missing, installation or repair of non electrical parts or systems near exposed or uncovered electrical panels, and work within electrical enclosures for testing, repair, or modification of any part of the device or system.