

**ILLINOIS INSTITUTE OF TECHNOLOGY**  
**SAFETY POLICY COMMITTEE**

**Electrical Safety**

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## **1. INTRODUCTION:**

This section presents the general safety requirements for work with electricity at Illinois Institute of Technology, and is focused on *standard electrical service*. Some hazards are inherent in the installation, maintenance, and use of electrical wiring and equipment. Control of most of these hazards is neither difficult nor expensive but ignoring them may lead to serious accidents. The primary IIT reference for electrical design and installation is NFPA 70, the *National Electrical Code*. Minimum safe work requirements in this section are based on 29 CFR 1910.333, "Selection and Use of Work Practices;" 29 CFR 1910.269, "Electrical Power Generation, Transmission, and Distribution;" 29 CFR 1926 Subpart K.

## **2. RESPONSIBILITIES:**

### **Chairs/Supervisors**

- Shall ensure qualification of all personnel performing electrical-related tasks on a case-by-case basis. See definition of Qualified Person below.
- Shall ensure that throughout their area of responsibility, the work environment presents a minimal level of risk, and shall identify all potentially hazardous activities within that area;
- Ensure the proper planning, design, code compliance, and commissioning of electrical installations. Persons involved in this process shall be qualified;
- Responsible for the orderly shutdown and removal of electrical equipment and cabling upon the completion of a project/program, to reduce the hazards of abandoned cables; and
- Ensure preparation of single-line diagrams and other appropriate documentation for all major electrical installations of scientific apparatus or machinery to facilitate its safe operation and maintenance. Scientific apparatus documentation shall be the responsibility of the controlling Department.

### **Department of Facilities Design and Construction**

- Shall prepare single-line diagrams for all modifications of electric service to the distribution point level in IIT buildings; and
- Maintain a current file of such changes, together with the building or area drawings.

### **Supervisors**

- Shall develop an attitude and awareness of safety in the people they supervise, maintain a safe work environment, take corrective action on any potentially hazardous condition;
- Oversee that in their areas of responsibility the provisions of this section are met. Specifically, supervisors shall ascertain that all electrical installations, maintenance, and inspections are performed by qualified employees and that personnel are protected by means of instructions, signs, barriers, or other appropriate vehicles;

- Ensure that all employees whose regular duties require that they may work with electric equipment are trained to:
  - Recognize electrical hazards;
  - Use warning signs properly;
  - Understand the necessity for guarding equipment;
  - Utilize safe operating procedures;
  - Dial 312-808-6363 or 911 in emergency situations; and
  - Utilize the Lockout/Tagout procedures when appropriate (see IIT Safety Policy Committee Lockout/Tagout Program).

Supervisors should conduct pre-job briefings for all non-routine electrical tasks to ensure that employees are aware of all job-specific safety requirements. Supervisors shall ensure that a hot work permit (See Hot Work Permit Procedure) or appropriate electrical safety procedures in accordance with the provisions of this section are employed for working on electrically energized circuits.

### **Employees**

- Shall become acquainted with all potential electrical hazards in the area in which they work;
- Learn and follow the appropriate standards, procedures, and hazard control methods;
- Consult appropriate supervision before undertaking a potentially hazardous operation and stop any operation they believe to be hazardous;
- Be a "Qualified Person" if work is to be done on electrical equipment;
- Notify the supervisor of any condition or behavior that poses a potential hazard;
- Notify the supervisor of any suspect cable that may be classified as abandoned;
- Wear and use appropriate protective equipment; and
- Immediately report any occupational injury or illness to IIT's Human Resources Department and to the employee's supervisor.

### **3. DEFINITIONS:**

**Electrical hazard** - Dangerous electrical condition recognized in a working area; examples include exposed energized parts, unguarded or damaged electrical equipment, and abandoned electrical cables and equipment.

**Hot work permit**- Required when working hot (electrically); stipulates work restrictions, precautions, and personal protective equipment requirements.

**Live part** - An electrically conducting part operating at a potential of 50 volts to ground or greater.

**Lockon/Tagon** - Procedure designed to ensure that essential equipment is not inadvertently disconnected from its power source.

**Lockout/Tagout** - Procedure designed to ensure that equipment or machinery is disconnected from its power source while installation, maintenance, testing, repair, and/or construction operations are in progress.

**Qualified Person** - An employee who has sufficient training and experience with the construction and operation of the electrical apparatus and the hazards involved to demonstrate to their supervisor that he/she is competent to complete the work to be done; see Training for Qualified Persons, below.

**Safety Watch** - A Qualified Person who provides dedicated support to a person performing electrical hot work when so required by the hot work permit.

**Temporary wiring** - Electrical wiring that is installed for a short period of time, such as experimental or construction set up.

**Working hot** - Performing work on an electrically charged circuit or in close proximity to an exposed electrical circuit where the possibility exists to come in contact with a live circuit of 50 volts or greater.

#### **4. TRAINING FOR QUALIFIED PERSONS:**

The training requirements contained in this section apply to employees who face a risk of electric shock that is not reduced to a safe level by the electrical installation requirements of 29 CFR 1910.303 through 29 CFR 1910.303. Employees who may reasonably be expected to face risk of injury due to electric shock or other electrical hazards must be trained. Training for Qualified Persons will include the following:

- The hazards and safety-related work practices that pertain to their specific job assignments.
- The selection, application, and proper use of personal protective equipment and insulated tools.
- The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.
- The skills and techniques necessary to determine the nominal voltage of exposed live parts.
- The clearance distances specified in 29 CFR 1910.333(c) and the corresponding voltages to which the Qualified Person will be exposed.

The training required by this section shall be of the classroom or on-the-job type. The degree of training provided shall be determined by the risk to the employee.

#### **5. SAFETY CRITERIA FOR EQUIPMENT:**

- 51 Design for safety.** Consider safety to be an integral part of the design process. Protective devices, warning signs, and administrative procedures are supplements to good design but can never fully compensate for its absence. Completed designs should include provisions for safety maintenance.

- 52 Maintain for safety.** Good maintenance is essential to safe operations. Maintenance procedures and schedules for servicing and maintaining equipment and facilities, including documentation of repairs, removals, replacements, and disposals, should be established.
- 53 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. Dispose of obsolete drawings and be certain that active file drawings have the latest corrections.
- 54 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 department head or above.
- 55 Have designs and operation verified.** All systems performing safety functions or controlling a potentially hazardous operation must be periodically validated by actual test procedures at least once a year, and both the procedures and actual tests must be documented.
- 56 Test equipment safely.** Tests should be made when the electrical equipment is de-energized, or at most, energized with reduced hazard.
- 57 CPR Training.** When performing electrical hot work requiring a Safety Watch, the Safety Watch must be trained and certified in cardiopulmonary resuscitation (CPR). Biennial recertification is required and must be documented with the department.

## 6. WORK PRACTICE:

All employees shall use the following work practices when working on electrical equipment and circuits:

- Only qualified employees shall undertake operations or work and shall be trained in emergency procedures for use in the event of an accident. Emergency procedures include use of the 911 system, contacting IIT Public Safety (312) 808-6363 and CPR for persons acting as a Safety Watch.
- De-energize a circuit before working on it; check with appropriate instrumentation (e.g., voltmeter). If the de-energized circuit can be inadvertently reactivated, the Lockout/Tagout Program described in [https://web.iit.edu/sites/web/files/departments/general-counsel/Lockout%20Tagout%20Draft%20Policy\\_Rev.%20Mar.09.2020\\_.pdf](https://web.iit.edu/sites/web/files/departments/general-counsel/Lockout%20Tagout%20Draft%20Policy_Rev.%20Mar.09.2020_.pdf) shall be utilized.
- Be extremely careful of abandoned electrical cables and equipment. Open ended wires must be insulated. Abandoned cables shall be reported to management and entered in HawkWorks, the on-line facilities request system, as candidates for removal.

- A positive barrier shall be used to prevent personnel or conductive material from contacting electrical current-carrying parts; bare energized parts shall not be left unattended without adequate guarding and warning.
- Be alert for stray currents from such paths as those caused by leakage (surface contamination), corona, or the ionizing path of a flame. Never enter a hazard area alone.
- Always use safety glasses as the minimum eye protection when fabricating or maintaining electrical equipment. See Appendix, section 3.
- Never wear metallic items (e.g., key chains, wristbands, watches, or rings).
- Metal ladders shall not be used
- Fish tapes shall not be used in raceways containing energized conductors.

## **7. ELECTRICAL CODE REQUIREMENTS:**

Electrical and electronic installations at IIT, including grounds, shall conform to the philosophy and intent of the current edition of NFPA 70, *National Electrical Code*. If an exception must be made, the issue shall be brought to the Department of Environmental Health and Safety for review and approval. The Department of Environmental Health and Safety may use the Department of Facilities for assistance in review.

Wherever applicable, recognized standards agencies and testing laboratories such as the Institute of Electrical and Electronic Engineers (IEEE), Underwriters Laboratories (UL), U.S. Bureau of Mines, and National Electrical Manufacturers Association shall be observed for electrical wiring, devices, and equipment.

All electrical equipment that requires access for maintenance and adjustments shall have a clear space maintained in the direction of access while energized, as established by the *National Electrical Code*, NFPA 70. Work space shall be not less than 30 inches wide in front of equipment. In all cases, the work space shall be sufficient to allow for at least a 90 degree opening of equipment doors or hinged panels. See NFPA 70, "National Electrical Code," Section 110-16 for specific working clearances around equipment of 600 volts or less.

All electrical and electronic wiring at IIT shall:

- Meet the requirements for which it is intended;
- Be protected by a grounded metal enclosure or raceway
- Be provided with wire terminal lugs where stranded wire is retained by a screw. Where space does not permit the use of terminal lugs, strands shall be soldered together to form a single conductor.

## **8. ELECTRICAL DISTRIBUTION AND CIRCUITS:**

Electrical control equipment must be readily accessible to authorized personnel but must be protected from accidental operation.

Switches and circuit breakers must clearly indicate whether they are open or closed. All new switches and circuit breakers must be capable of being locked in the open (off) position.

Where feasible, all consoles or similar secondary distribution/control systems shall be labeled with information identifying all of the power panels, breaker locations, voltage and phase information, etc., pertinent to feeding the secondary system. Such information should be conspicuous.

Safety interlocks shall be tested at least annually to ensure operability.

Electrical interlocks and other safety devices shall not be bypassed except when absolutely necessary and only with written approval from the supervisor and an approved standard operating procedure which addresses these bypasses.

Breakers, switches, and other devices to be installed shall be appropriate for the intended use.

All devices shall be functional and have satisfactorily passed the manufacturers and field tests as required for safe installations.

Special precautions and techniques shall be employed when adding components to an energized system to ensure the safety of workers in event of component failure.

## **9. WORKING HOT:**

Work involving potentially injurious electrical circuits shall not proceed unless all involved personnel have followed the procedures and complied with the requirements of the Lockout/Tagout Program, or have satisfied the requirements for working hot electrically, outlined below.

The following procedures for working hot electrically apply to all new installations as well as to all maintenance and troubleshooting operations that are performed on operative equipment.

Every effort shall be made to de-energize and lockout/tagout electrical equipment according to the Lockout/Tagout Program before any work is started. In the event that working hot is necessary, definitive procedures must be followed to minimize the hazards to employees and contractors.

1. A "Hot Work Permit (Electrical)" must be processed and approved prior to start of work. See the attachment at the end of this section.
2. Annual hot work permits may be issued to qualified groups. However, every task performed under the annual permit must be approved by a supervisor competent in electrical safety.
3. All requirements of this section must be followed except for those operations specifically excluded by item 11 below.
4. One person must be appointed as a dedicated Safety Watch when the Hot Work Permit so stipulates.



5. The Safety Watch must be able to cut off all power sources and shall be responsible for seeing that all protective devices and procedures are used and that all safety requirements are met.
6. The Safety Watch must be CPR trained and have immediate access to a telephone or radio to call for emergency assistance.
7. Persons performing the hot work shall obtain complete knowledge of the circuitry involved from study of the physical system and/or up-to-date drawings of the facilities and of the equipment. All points of de-energizing (both manual and automatic), as well as all energizing sources, must be known. Voltage and other electrical characteristics must be known.
8. All power sources must be provided with adequate fault/overcurrent protection.
9. Workers shall use appropriate insulated tools, rubber goods, and personal protective equipment as stipulated on the Hot Work Permit and/or required by good practice.
10. For other than routine tasks, safe procedures must be written.
11. Routine electronic and electrical work of a developmental or testing nature may not require a hot work permit or a Safety Watch, but shall require definitive procedures and posted house rules of electrical safety. Department Heads shall ensure that such procedures and house rules of electrical safety are subject to an annual safety review.

Department Heads shall ensure that the person performing this work is properly trained and qualified. In addition, the principles of protection listed below shall be adhered to as applicable where lethal electrical shock could occur.

## **10. PRINCIPLES OF PROTECTION:**

Each of the following principles of protection must be applied either through work practices or the use of equipment as specified below (or an approved equivalent). See appendix, “Electrical Personal Protective Equipment,” for specific guidance on use, storage, inspection, and testing.

- 101** Isolate and insulate the worker from all contact with ground potential by the use of such devices as linemen's rubber mats, blankets, sleeves (all inspected and tested), insulated objects such as phenolic sheets, dry boards, rubber soled shoes (no nails), and mechanical barriers (insulated).
- 102** Insulate the worker from contact with energized parts by using insulated tools, linemen's rubber gloves with over gloves of leather, linemen's rubber sleeves, mats, blankets (tested), and insulated barriers. Do not depend on the insulation on energized wires for protection; it may have cracks, nicks, scratches, tears, burns, or contaminants. All tools used for electrical work must be insulated sufficiently to protect the worker in the normal use of the tool. Linemen's gloves must be tested and rated for more than the voltage of the energized parts. Insulated barriers should prevent anyone from falling or leaning into live parts and should also contain any live part or prevent any live part such as a wire, cable, or bus bar from falling onto people or grounded metal.

- 103** Ground all noncurrent-carrying parts that may become accidentally energized by a shorting tool or object or a falling wire in order to prevent shock to grounded persons. The grounding of electrical equipment offers errant electricity a path of low resistance in the event of a breakdown of internal insulation; thus the user is protected by virtue of his higher resistance. In the ungrounded condition, electrical equipment may operate quite satisfactorily with an internal short until the user is in contact with it and some source of ground, such as a water pipe, radiator, steel building frame, or wet floor, resulting in a surge of current through the body and severe shock or death.
- 104** Insulate tools and other objects that touch the energized parts from accidental arcing to ground potential. Example: a screwdriver should have an insulated sleeve over the blade as well as an insulated handle.
- 105** Protect personnel from the radiation and splatter of accidental arcing by the use of safety glasses. Long sleeves, buttoned shirt, non-conductive natural fiber clothing and hard hat should be worn.
- 106** Instruct the Safety Watch or helper to be ready to instantly de-energize all power. It may be necessary to have a remote control cord in some cases.
- 107** Restrict nonparticipants from the scene using barricades, ropes, warning signs and lights, and the Safety Watch.

## **11. TEMPORARY WIRING AND EXTENSION CORDS:**

Temporary wiring will be permitted for a period not to exceed ninety (90) days for experiments or research projects. For construction or remodeling purposes, the period shall not exceed one (1) year. Temporary wiring must be installed so that it will not create hazards and should be run overhead at a minimum clearance of seven (7) feet wherever practicable. Wires/cords that run across floors shall have bridges over them to eliminate physical damage and minimize the tripping hazard.

Extension cords shall not be:

- Attached to building surfaces;
- Run through building walls, ceilings, doorways, or windows;
- Spliced, taped or modified in any way;
- Concealed behind building walls, ceilings, or floors;
- Wired so that an exposed male plug is energized;
- Used as a substitute for fixed wiring of a structure;
- Connected in series (see NEG Art 400-7 [b]).

## **12. PORTABLE ELECTRICAL TOOLS:**

All portable electrical equipment (except double-insulated tools) must be grounded when connected to a power outlet. Double-insulated tools must have a polarized plug or a 3-prong

grounding plug. The user shall inspect portable electrical equipment for defects before operation. Defective Equipment must be removed from service until repaired.

### **13. LOCKON/TAGON:**

There are energy sources at IIT that may require lockon and/or tagon. These are primarily electrical circuits that directly affect personnel safety (critical loads) or protection of property (essential loads). Examples of critical loads are fire alarm and life safety systems, fire pumps, exit/night lighting, certain telephone equipment, radiation monitoring devices, and similar applications. Essential loads may include sump pumps, certain heating controls and devices, control power to most central security system alarm circuits not characterized as critical, certain computer circuits, certain experimental circuits, and other applications that could cause significant loss of property if de-energized.

Lockon/tagon is preferable for essential and critical circuits, but tagon alone may be used where it is not feasible to lock on the circuit control device.

The Department of Facilities is responsible for the control and documentation of lockon/tagon of critical and essential circuits.

- Department of Facilities and Department Head approval must be obtained before circuits are locked on or tagged on.
- A log shall be maintained that lists all circuits locked on or tagged on, dates, and reason for the lockon/tagon.
- Tag must indicate the reason the circuit is locked on, date the lock was applied, and who is retaining the key.
- An annual audit shall be conducted of loads that are locked on and/or tagged on.

### **14. HAZARDOUS LOCATIONS:**

IIT follows NFPA 70 (National Electrical Code), articles 500 through 504. The articles cover the requirements for electrical equipment and wiring practices to be used in any location where fire or explosive hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flings.

### **15. HIGH VOLTAGE ELECTRICAL OPERATIONS:**

IIT houses a number of operations with apparatus in the kilo to mega volt range; associated with them are hazards not encountered in standard electrical service. Safe work in such environments requires special training, equipment, and procedures, established and maintained by The Department of Facilities, but not covered in this section. IIT personnel are required to adhere to the special safety provisions of each operation in addition to the requirements of this section.

### **16. VERY HIGH RADIATION AREAS INSPECTION:**



## **Appendix A**

### **ELECTRICAL EQUIPMENT MARKING AND IDENTIFICATION GUIDELINES**

This procedure is issued as a recommended practice. Any comments and/or observations should be forwarded to the Department of Environmental Health and Safety.

#### **Purpose:**

This procedure standardizes labeling of electrical equipment in such a manner that the voltage, feed source, and load can be readily recognized and seeks to standardize any other markings and color schemes necessary in order to enhance safety for those operating or maintaining electrical equipment.

It is not the intent of this procedure to force a complete change of all electrical markings throughout IIT. The procedure intends to establish a goal that can be achieved in time as old markings are replaced, new equipment installed, or new facilities commissioned. It is recommended that specifications for equipment markings for new facilities be included in engineering design drawings and specifications for electrical installations.

#### **Applicability:**

This procedure applies to all equipment hardwired to the electrical power distribution system. Markings in existence at the time of approval of this procedure need not be replaced as long as the intent of this guideline is met.

#### **Basic Protocol:**

The fundamental policy for identifying electrical equipment is as follows: identify the voltage, source, and load followed by a location identifier. The location identifier may consist of floor, wing, room and/or other identifying information to facilitate the source/load location in case of emergency, or for safety purposes in implementing lockout/tagout procedures. See example below.

#### **Marking Procedures:**

Full names of equipment should be used in lieu of abbreviations. Abbreviations should be used only in instances where the space available for placing such markings is too small. An abbreviation should clearly suggest the unabbreviated name of the equipment it identifies.

Abbreviations published by the Institute of Electrical and Electronic Engineers (IEEE) and/or those suggested by the Instrument Society of America (ISA) should be used to the maximum extent possible.

#### **Marking Guidelines:**

Equipment labeling information is as follows:

- Type equipment
- Voltage
- Source identification and location
- Load identification and location

**Color and Size:**

All electrical equipment identification and location labeling will be done using black letters on yellow background or, as an alternate, black letters on white background. Size of lettering should be proportional to the size of the equipment being labeled. Markings should not exceed more than 20% of the surface area of the equipment to be labeled.

Circuits fed from an emergency power source will have markings made with red letters over a white background. As an interim procedure, markings can be made with black letters over a white background with the upper and lower edges of the label highlighted with red vinyl tape until the appropriate label material can be obtained.

**Quality and Type:**

Identification markings for outdoor use can be made with vinyl tape covered with transparent plastic protectors, engraved metal signs or any other material suitable for outdoor use. For indoor use, vinyl or mylar tape or a similar type material is adequate.

## Examples

The following are examples of the minimum labeling.

### Motor Control Center Nameplate

MOTOR CONTROL CENTER MCC-1  
480VOLTS  
SOURCE: SUBSTATION A, BREAKER A

### MCC-1 Breaker A4 Nameplate

A4  
LOAD: EXHAUST FAN EF-1  
LOC: WING B, ROOF, NE

### Fusible Disconnect

DISCONNECT SWITCH FOR EXHAUST FAN EF-1  
480 VOLTS  
SOURCE: MCC-1 BREAKER A4  
LOC: SERVICE FLOOR WING B  
LOAD: EXHAUST FAN EF-1  
LOC: WING B, ROOF, NE

### Exhaust Fan 1 Nameplate

EXHAUST FAN EF-1  
SOURCE: MCC-1 BREAKER A4  
LOC: SERVICE FLOOR-WING B

### Exhaust Fan 1 Nameplate (Powered by emergency source)

EMERGENCY SERVICE CIRCUIT  
  
EXHAUST FAN EF-1  
SOURCE: MCC-1 BREAKER A4  
LOC: SERVICE FLOOR-WING B

### Character Heights (for guidance only)

Intended Viewing Distance	Minimum Height	Recommended Height
1 ft. 8 in. or less	0.09 in.	0.16 in.
1 ft. 8 in. to 3 ft.	0.17 in.	0.28 in.
3ft to 6ft	0.34 in.	0.56 in.
6ft to 12ft	0.68 in.	1.12 in.
12ft to 20ft	1.13 in.	1.87 in.

### Markings of Panel boards and wall receptacles

By far panel boards and wall receptacles are the two types of electrical equipment most prevalent throughout IIT and the equipment with which most employees are familiar and use the most. This equipment calls for detailed markings that will assist the user in readily locating the source in case of emergency, and for maintenance personnel to locate the equipment quickly. The following markings are suggested.

#### Panel boards

- Voltage
- Panel board designation with type, number and location

#### Wall Receptacles

- Voltage (if other than 120 V AC)
- Panel board number
- Circuit breaker number



## **Appendix B Policy for Abandoned Cables**

There are safety issues associated with abandoned power cables and equipment. The failure to properly de-energize, terminate, and identify abandoned cables can become the root cause of electric shock. Contributing causes can include general problems with labeling, documentation, housekeeping, and decommissioning procedures for experimental areas.

Additional issues to be considered are:

- Insulating materials that produce toxic fumes under fire conditions,
- Space requirements,
- Improper terminations,
- Rising disposal costs (that will have to be paid eventually),
- Tracing the history of a particular installation,
- The lifetime of equipment,
- The belief that most abandoned power equipment eventually will be used by someone.

All abandoned power cables and associated equipment must be removed according to this abandoned power cable policy. In addition, the Department of Environmental Health and Safety notes that similar hazards exist for abandoned signal cable and telephone equipment. This policy also applies to signal cable and telephone equipment.

### **Policy:**

Whenever feasible, abandoned cables and associated equipment should be removed back to the power source. Where removal is not feasible, abandoned cables shall be properly terminated at both ends and labeled.

### **Policy Criteria and Definitions:**

- **Suspect of abandonment** - Any power cable that is not in service will be classified as suspect of abandonment.
- **Abandoned** - A power cable that has been identified to be suspect of abandonment and ownership cannot be established among the parties involved or ownership has been established but no future use is planned will be classified as abandoned.
- **Future use** - When ownership of a suspect power cable has been established and the owner has a need for future use, a written justification of such would be required to keep the cable from becoming classified as abandoned. Documentation will be retained by the building manager. The future use justification would require a date of expected use and incorporate a date which upon expiration would classify the cable as suspect once again. When a power cable has been slated for future use, the cable would have to be properly terminated, labeled, and documented in the electrical diagrams (single line) for the area.

- **Removal** - All cables and associated equipment that are classified as abandoned should be removed back to the source. At the termination of a project, the responsible project personnel, Department Head, Facilities Representative, and a representative for the Department of Environmental Health and Safety, will concur on the feasibility of removal of all related power cables and equipment. Where removal is not feasible, cables will be properly terminated at both ends and labeled.
- **Disposal** - All cables and associated equipment that have been removed will be disposed of in an environmentally safe manner.

## **Appendix C**

### **Electrical Personal Protective Equipment**

#### **Introduction:**

Appropriate personal protective equipment be used to protect employees from electrical hazards. Employees authorized to work on systems with live voltage shall be familiar with the appropriate protective requirements. In addition to the proper use of these items, this requirement extends to rules regarding proper storage, inspection, and testing.

Safe work practices shall be used to safeguard employees from injury while they are working on or near electrical circuits or equipment. De-energization and use of lockout/tagout are required whenever possible. When it is not feasible to de-energize and lockout/tagout electrical circuits and equipment, appropriate work practices and safeguards must be implemented to protect the employee from injury.

Any work on or near exposed energized surfaces requires the processing and approval of a Hot Work Permit (Electrical) prior to the start of electrical work. As part of the safety analysis for issuing a Hot Work Permit, the required personal protective equipment is defined as required to provide maximum safety to the electrical worker. As provided for in the Electrical Safety Procedure, routine electronic and electrical work of a developmental or testing nature may not require a hot work permit. In these cases, however, house rules of electrical safety are required and they should address the personal protective equipment to be used.

This appendix discusses the personal protective equipment that may be required for a specific electrical work project. All electrical personal protective equipment used at IIT must meet the requirements in this appendix.

Issues covered in this appendix for each type of personal protective equipment as applicable are:

- Recommendations for use and nonuse
- Class/Voltage rating for insulation equipment
- Purchase specifications
- Handling, storage and inspection prior to and during use
- Periodic laboratory testing certification requirements

Some information is covered in other IIT Policies and Procedures and is merely referenced in this appendix.

#### **Responsibilities:**

**Deans, Department heads and supervisors** shall provide required personal protective equipment to their employees. They shall ensure that purchased equipment meets the specifications referenced in this appendix and that required laboratory testing is performed. They shall also ensure that employees are qualified and trained in the proper use and care of personal protective equipment.

**Employees** must properly use all personal protective equipment specified by the relevant Working Hot Permit, house electrical safety rules, job procedures, or their supervisor's directions. They must also follow the use, handling, and storage procedures specified in this appendix.

### **Definitions:**

**Energized (electrically)** - see "live" below.

**Insulated** - Separated from conducting surfaces by a dielectric substance that offers a high resistance to the passage of electrical current.

**Insulated tools** - Resemble standard hand tools such as pliers, screwdrivers, wire strippers, etc. In addition, however, the grips and sometimes shafts and other surfaces of the tools are covered with or made of an electrically insulating material to provide protection from electrical shock for the user.

**Insulating hard hat** - A hard hat that has a special shell designed and specified to provide protection from electrical shock up to a specified voltage.

**Live (electrically or voltage)** - A piece of equipment or a device that contains any exposed conductors with a voltage greater than 50 V either DC or RMS AC.

**Ozone** - A chemically active form of oxygen (chemical formula O<sub>3</sub>) that may be produced by corona, arcing, ultraviolet rays, high electric field or other ionization process.

**Rubber** - A generic term that includes elastomers and elastomeric compounds, regardless of origin, that are electrically insulating.

**Voltage** - Refers to the maximum RMS or DC voltage difference between any two conductors or a conductor and ground that exists in or near the work area that could possibly be contacted.

### **Safety Glasses:**

The brief guidance here describes only requirements specific to use of safety glasses with electrical hazards. Safety glasses and/or goggles shall be worn any time a person is working electrically hot or otherwise working near open, live electrical components. In these cases, metal-framed safety glasses shall not be worn. Instead, the frames shall be made of plastic or other electrically insulating material.

### **Insulating hard hats:**

Insulating hard hats (helmets) should be worn any time there is a possibility of accidental contact by the head with any live electrical wires, conductors, or other conducting surfaces. Class A hard hats are acceptable for electrical hazards having a maximum voltage of 2200 volts. If contact with any conductor above this voltage is possible, Class B hard hats are required. Class A hard hats shall meet specification ANSI Z89.1 - Class A. Class B hard hats must meet the requirements of ANSI Z89.1 - Class B. Class C and other metal hard hats **cannot** be used near electrical hazards.



**Insulated tools:**

Insulated tools shall be used any time a person is using hand tools on or near live electrical conductors. They are to be used for voltages up to 1000 volts only. Above that voltage, special tools are required- see the "Electric Utilities Service Workers Safety Manual" for further information.

The only type of insulated tools within the scope of this description is those with the internationally recognized symbol:



Insulated tools must meet the requirements of specification ASTM F1505 or the IEC 900 standard as verified by displaying the symbol noted above. Dipping tools in plastic or wrapping handles with electrical tape does **not** meet the requirements of an insulated tool.

Standard care is required for insulated tools as for any other tool. In addition, the insulating grips should be kept away from sharp edges, wire clippings, and other materials that could pierce the insulation. The tools shall be kept clean. Solvents and other chemicals that could chemically attack the grip material should be stored and used clear from these tools. The provided package or a tool case that prevents the tool from contacting other tools and objects during storage is preferable.

Before each use, insulated tools shall be visually inspected. In addition to normal checks for a standard tool of the same type, the grips should be visually inspected for cracks, holes, discoloration or wear. Do not use a tool that fails this inspection. Insulated tool grips usually have outer and inner insulation layers of contrasting colors. If the inner color is visible at any point through the outer layer, the tool shall be taken out of service.

**Rubber Protective Goods:**

Rubber protective goods cover a large group of items including protective clothing and equipment such as rubber insulating gloves, line hose, blankets, matting, covers, and sleeves. Their common purpose is to place a physical insulating barrier between workers and electrically energized surfaces.

In-depth information on various rubber protective goods can be found in the following references. All rubber electrical personal protective equipment used at IIT must meet these specifications.

ANSI/ASTM 0120	Specifications for Rubber Insulating Gloves
ANSI/ASTM F696	Specifications for Leather Protectors for Gloves
ANSI/ASTM 0178	Specifications for Rubber Insulating Matting
ANSI/ASTM 01048	Specifications for Rubber Insulating Blankets
ANSI/ASTM 01049	Specifications for Rubber Insulating Covers
ANSI/ASTM 01050	Specifications for Rubber Insulating Line Hose
ANSI/ASTM 01051	Specifications for Rubber Insulating Sleeves

Rubber goods are divided into a number of **classes** based on their maximum insulating ability. These classes are defined in the following table. The associated label color used to define the class is also given.

Tag Color	Class	Proof Test Voltage AC/DC	Max. Usage Voltage AC/DC
Beige	00	2,500/10,000	500/750
Red	0	5,000/20,000	1,000/1,500
White	1	10,000/40,000	7,500/11,250
Yellow	2	20,000/50,000	17,000/25,500
Green	3	30,000/60,000	26,500/39,750
Orange	4	40,000/70,000	36,000/54,000

Any piece of rubber protective equipment with a higher class can be used for a lower class application. For example, a Class 2 *glove* could be used by a technician working on a 5 kV circuit. The converse is not true. You must not use a lower class of glove for a higher class of voltage. For example, a Class 1 glove cannot be used on a 15 kV circuit.

Generally two types of rubber goods (Type I and Type II) are available. Type I rubber goods are **not** resistant to ozone. Exposure to ozone may result in deterioration of the article. Therefore, Type I articles should not be used near arcs, ultraviolet light, and other possible sources of ozone. Type II rubber goods are generally resistant to ozone and may in some cases have additional properties such as fire or oil resistance. The user should be familiar with the types of a specific item to be used. Use the proper type of rubber good based on the characteristics and other materials in the work area.

Some rubber protective goods come in various **styles**. Styles refer to additional physical properties. The individual specifications referenced above should be consulted for additional information about styles. The physical characteristic specified by the term style depends on the particular rubber good. For example, for rubber insulating blankets, style A blankets contain no reinforcement, while style B blankets incorporate a reinforcement.

Use the rubber personal protective equipment specified for the task as listed in the Hot Work Permit or in the house electrical safety rules as appropriate. In general, rubber insulating gloves and rubber matting will be required for most tasks. Leather or FR gloves shall be worn where required for arc flash protection. Where insulated gloves are used for shock protection, leather protectors shall be worn over the rubber gloves. When voltages exceeding 500 V are present, the next higher class of glove must be used.

Care, maintenance, and testing of rubber protective equipment is dependent upon the particular item being used. The user must be familiar with and comply with the manufacturer's instructions regarding use, care, maintenance, and testing.

Some general rules apply to most rubber goods:

- They should be stored in a clean, dry, cool location.
- Use the specific storage container provided for items when available.
- Do not expose rubber goods to sunlight, excessive heat, or allow them to be creased or folded unnaturally or otherwise bruised or scuffed.
- Always visually inspect for possible damage, excessive wear, and other defects before use. If the inspection reveals a possible defect, do not use the item. Get a new replacement.
- Never stretch rubber protective equipment.
- Do not expose rubber equipment to solvents, gasoline, oil, or other chemicals.
- Never repair a defective item. Instead, replace it with a new one.
- Keep an equipment and testing log for each item.
- Use serial numbers to track who has possession of the various pieces of equipment.
- Ensure that major tests are performed on time at a qualified laboratory and by competent people.

Testing intervals are specified in OSHA regulations 29 CFR 1910.137(b) (2) and the associated Table 1-6. These regulations require tests by a qualified laboratory as follows:

<b>Type of Equipment</b>	<b>When to test</b>
Rubber insulating gloves	Before first issue and every 6 months thereafter.
Rubber insulating sleeves	Before first issue and every 12 months thereafter
Rubber insulating blankets	Before first issue and every 12 months thereafter
Rubber insulating covers	Upon indication that insulating value is suspect
Rubber insulating line hose	Upon indication that insulating value is suspect

The test before first use is not required if the manufacturer performed appropriate testing. If so, that effective test date for purposes of the following paragraph will be the purchase date.

Electrical testing of gloves shall be valid for a 12-month period. All in-service gloves must be tested every 6 months. Gloves may be stored for a period not exceeding six months prior to being considered in service. Whether placed in service or not, all gloves must be tested at least every 12 months.

For further information or a list of qualified testing laboratories, contact the Department of Environmental Health and Safety.

## Appendix D



## Degree of Electrical Hazard

The current from 110-120 volt circuits kills more people annually than the so called "more dangerous" high voltages. This is probably attributable to the high exposure potential, lack of awareness of the danger, failure to correct obvious defects in wiring, or just plain chance taking. When any part of the body becomes part of an electrical circuit, three factors determine the severity of the shock: the actual *quantity* of current through the body, the *path* of the current through the body, and the *duration* or time the current flows through the body.

The most important variable is the current itself. This quantity of current is dependent on the resistance offered to its passage. Applying Ohm's law, current through the body ( $I$ ) is equal to the voltage applied ( $E$ ) divided by the resistance of the body ( $R$ ), or  $I=E/R$ . Thus, a decrease in the ohms of resistance causes a corresponding increase in the current while the voltage remains constant.

### Human Resistance to Electrical Current.

Body Area	Resistance
Dry Skin	100,000 to 600,000
Wet Skin	1,000
Internal body (hand to foot)	400 to 600
Ear to ear	(about) 100

The above values of human resistance will, in general, be lower at increasing values of through-current. A conservative overall figure for human resistance in the path of the ground fault current (for use in a hazard evaluation calculation) would be 500 ohms.

Contrary to common perception, low alternating current is dangerous, particularly if the pathway of the current is through the heart (see Table 1), causing ventricular fibrillation, a rapid, uncoordinated, repeated contraction of the ventricles of the heart resulting in loss of synchronization between the heartbeat and the pulse beat. Once ventricular fibrillation occurs, death follows in a few minutes. Cardiopulmonary resuscitation, if applied immediately, can save the victim.

**Table 1**

Current	Effect
0.5 - 3 mA	Tingling sensations
3 - 10 mA	Muscle contractions (painful)
10 - 40 mA	"Can't Let Go" phenomena
30 - 75 mA	Respiratory paralysis (possibly fatal)
100 - 200 mA	Ventricular fibrillation (likely fatal)
200 - 500 mA	Heart clamps tight
1.5 A	Tissue and organs begin to burn

A 100-ma current flowing for 2 seconds through a human adult body will cause death by electrocution. This doesn't seem like much current when you consider that a small, light-duty

portable electric drill draws 30 times that much. However, because a current as small as 3 mA can cause painful shock, it is imperative that all electrical equipment plugs, cords, and extension cords be kept in good condition and connected to a properly wired grounded circuit.

There are four basic rules of electrical action that everyone should know. They are as follows:

**1. Electricity doesn't spring into action until current flows.** You can carry and use faulty power tools with live metal cases without causing a shock until you come in contact with a ground loop of low resistance.

**2. Electrical current won't flow until there is a complete loop.** That is, a loop from the voltage source back to the voltage source. The current will then flow since there is a way for the electricity to return to the source or the grounded transformer secondary. If a bird is sitting on a power line, no current flows through the bird's body since there is no loop back to the transformer.

**3. Electrical current always returns to its source.** In a grounded transformer secondary system, electrical current will not only use the earth as a return path, but any other loop path available to get back to its secondary. Building beams, water pipes, metal ventilation ducts, metal studs in modern wall construction, and metal raceways are examples of other ground loops.

**4. When current flows, work (measured in watts/joules) is accomplished.** Since the body is considered a resistive load, getting in a current loop will cause injury. High voltage and high current can cause irreversible bodily harm.

**Attachment 1  
Hot Work Permit (Electrical)  
(post a copy at the job site)**

<b>Department</b>	<b>Building</b>	<b>Room</b>	<b>Other</b>
<b>Job Supervisor</b>		<b>Date Start</b>	<b>Date Complete</b>
<b>Job Description (Justification for working):</b>			

**Safety Checklist (check requirements appropriate for this task):**

	Safety glasses with Side shields, or safety goggles
	Remove all jewelry and metal objects
	Insulated hard hats (appropriate ANSI class)
	Insulated tools
	Insulated rubber gloves
	Insulated barriers or rubber blankets placed to keep any person or object from touching or falling on live parts
	Insulated rubber matting
	Barricades and warning signs
	Worker must be qualified and have full knowledge of equipment
	Safety watch is required. This person must be qualified, have knowledge of equipment, be able to cut off all power sources, have current CPR training, and have immediate access to a telephone or radio to call for emergency assistance.
	Facilities Engineering Review
	See attachment for added information and procedures
	<b>Special Requirements:</b>

**Approvals**

Prepared by:	Date:
Job Supervisor:	Date:
Facilities Department Head	Date
Project Manager:	Date
Safety Officer or Representative:	Date
Person performing work::	Date

## Working Hot Requirements

- Work involving potentially injurious electrical circuits shall not proceed unless all involved personnel have followed the procedures and complied with the requirements of The Lockout/Tagout Program, or have satisfied the requirements outlined below.
- The following procedures for working hot electrically apply to all new installations as well as to all maintenance and troubleshooting operations.
- Every effort shall be made to de-energize and lockout/tagout electrical equipment according to The Lockout/tagout Program before any work is started. In the event that working hot is necessary, specific procedures must be followed to minimize the hazards to employees and contractors:
  1. A Hot Work Permit (Electrical) must be processed and approved prior to start of work.
  2. Annual Hot Work permits may be issued to qualified groups. However, every task performed under the annual permit must be approved by a supervisor competent in electrical safety.
  3. One person must be appointed as the Safety Watch when the Hot Work Permit so stipulates.
  4. The Safety Watch must be able to cut off all power sources and shall be responsible for seeing that all protective devices and procedures are used and that all safety requirements are met.
  5. The Safety Watch must be CPR trained and have immediate access to a telephone or radio to **call 911** and IIT Public Safety (312) 808-6363 in case of emergency.
  6. Persons performing the hot work shall obtain a complete knowledge of the circuitry involved from study of the physical system and/or up-to-date drawings of the facilities and of the equipment. All points of de-energizing (both manual and automatic), as well as all energizing sources, must be known. Voltage and other electrical characteristics must be known.
  7. All power sources must be provided with adequate fault/overcurrent protection.
  8. Workers shall use appropriate insulated tools, rubber goods, and personal protective equipment as stipulated on the Safety Checklist (front of this permit) and/or required by good practice.
  9. For other than routine tasks, safe procedures must be written.