ANL Physics Division

ELECTRICAL SAFETY POLICY AND MANUAL

2007

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Electrical Safety Policy

In keeping with the Physics Division Policy to give the highest priority to Environmental, Health, and Safety concerns in its operations, it is the intent of Physics Division management to prevent electrical hazards to staff and visitors and to assure adherence to applicable electrical safety codes. This will be accomplished through the development of operational procedures, the proper training of personnel, the design of equipment, and the establishment of an Electrical Safety Committee.

ELECTRICAL SAFETY COMMITTEE CHARTER

Authorization

The Physics Division Electrical Safety Committee is authorized by and reports to the Director of the Physics Division.

Responsibilities and Functions

- The committee serves as an internal review committee that advises Division management on all issues related to electrical safety within the Division
- Develops and revises as needed the Physics Division Electrical Safety Policy and Manual.

Insures that Lock-out/Tag-out log books are reviewed annually. Ensures or oversees completion of the annual review of Lockout/Tagout procedures and authorized employees". [References include ES&H Manual 7.1.3, NFPA 70E 120.2(C)(3), and OSHA 29CFR1910.147(c)(6)].

- Identifies unsafe conditions and/or practices and assist in the development of remedial action plans.

$ Reviews electrical incidents, near-misses, and formulate preventive measures.

$ Performs electrical safety inspections as required.

$ Document meetings, inspections, and other activities with regard to electrical safety.

$ Works to increase the level of electrical safety and electrical safety awareness within the Division.

Composition

- The Physics Division Electrical Safety Committee shall consist of at least three Physics Division members appointed by the Division Director and a member from EQO. The Physics Division members shall be significantly involved in electrical work.
- One member from the Physics Division shall be designated as Chairman of the Committee.
- Ad hoc members will be invited to participate in specific experimental electrical safety reviews or when membership expertise needs to be expanded.

Frequency of Meetings

This Committee will convene at least semi-annually in order to fulfill the responsibilities and accomplish the mandates as specified in this Charter.

Physics Division Electrical Safety Manual

I. NATIONAL AND LOCAL STANDARDS

As a minimum requirement, all equipment and facilities shall meet the following specifications:

1. Must be in compliance with the National Electrical Code (NEC) edition in force at the time the equipment or facilities were constructed;

2. Must be listed by a Nationally Recognized Testing Laboratory (NRTL), where equipment is so available, or must be reviewed and certified as required by the ANL Electrical Safety Committee

3. Should meet the guidance in the DOE Electrical Safety Handbook,

4. Must be in compliance with the Argonne National Laboratory's ESH Manual,

5. Physics Division Electrical Safety Manual.

6. Any exceptions to the Physics Division Electrical Safety Manual and/or the ANL ESH Manual must be reviewed and approved by the Physics Division Electrical Safety Committee. Included in the review will be an evaluation of any compensatory measures taken to eliminate potential hazards created by the exceptions.

7 All experimental equipment must be reviewed as required by the Physics Division, including an electrical inspection and certification by a Designated Electrical Equipment Inspector prior to its operation. The installer shall be responsible for

removing his experimental or temporary installations immediately after use.

II. SUPPLEMENTARY STANDARDS

The contents of this manual are supplementary to NEC and the ANL ESH Manual, Chapter 9, to cover the unique electrical hazards at ATLAS and the Physics Division.

III. POWER AND DISTRIBUTION CIRCUITS

A. Outlets and Power Supply Outputs

1. DC power supply outputs shall be marked to identify polarities, midpoint or neutral and grounded or ungrounded terminals.
2. Cube taps shall not be used.
3. Extension cords must not be attached to the building or located such as to cause a tripping hazard.
4. Extension cords are only acceptable for temporary use. If a cord is required to be used for more than 90 days, contact the Division's ESH Engineer, Tom Mullen (2-2879) for guidance.
5. Any cord located in a walkway must be covered by a tunnel made for such use.

B. Conductors Electrical conductors shall have adequate mechanical protection and support. Cables must be channeled in an orderly manner, in cable tray or conduit wherever possible. All phases and the return or ground conductors over size No. 10 of each individual circuit shall be laced or bundled together and have adequate mechanical support in case of a short. No wires or other equipment shall be attached to or suspended from the building sprinkler system.

C. Circuits

1. Circuits shall have over-current protection and disconnecting provisions.
2. High-voltage (>600 volts) or high-current (>30 amps) electrical circuits shall have design consideration given to safe and multiple emergency shutdown provisions
3. Circuits and equipment shall be designed and selected to be safe in case of a power failure or an automatic return of power after a failure.
4. Circuits with stored energies of 10 joules or more shall have provisions for safe discharge.

IV. SYSTEM NEUTRAL

Each circuit with grounded or ungrounded neutral shall have an insulated current-carrying return conductor that shall not be used for equipment ground. Floating electrical systems shall be avoided unless necessary for the proper operation of the equipment.

V. EQUIPMENT GROUNDING

Exposed non-current carrying metal parts of electrical equipment shall be grounded (connected to earth or building common system ground). Metallic adjustment shafts that protrude through chassis panels shall also be grounded. The ground conductors shall be of adequate size to carry the maximum possible fault current expected during operation. They shall be connected to common system ground. Ground conductors in AC circuits are not current-carrying during normal operation. They are for personnel safety only.

VI. EXPOSED LIVE PARTS

A. Exposed live voltages on parts of electrical equipment shall be protected from inadvertent contact by parts of the body, small tools, or loose hardware if the voltages are greater than 50 volts or if carrying a current greater than 20 amperes. This shall be accomplished by means of enclosures or barriers which cannot be removed without the use of tools.

B. Rear control-room panel areas that have 120 volts or lower exposure, where it is impractical to cover every termination, shall be properly identified as to the hazard and access limited to qualified personnel. Entrance(s) to the areas shall be locked at all times unless they are occupied and shall be prominently labeled as to the hazard inside.

VII. ELECTRICAL EQUIPMENT PROTECTIVE MEASURES

A. Electrical equipment operating at potentials from 50 to 600 volts or utilizing currents of 20 amperes or more shall meet the following requirements:

1. Equipment shall be labeled with an ASA sign, "CAUTION -- HIGH VOLTAGE" (if over 120 volts) and/or "CAUTION -- HIGH CURRENT, VOLTS MAX" and/or "AMPS MAX.

2. The main disconnect switch or circuit breaker shall be identified as to what it supplies.

3. The equipment shall be enclosed and grounded (see Sections V and VI).

4. All terminals or exposed non-insulated parts of the circuit shall be protected by means of enclosures or barriers. Access to the terminals or exposed non-insulated parts cannot occur without the use of tools.

5. All plugs and connectors shall be of the type in which the body or ground conductor contacts its mating part before the circuit conductor makes contact and shall be of dead-front type construction.

B. Electrical equipment operating at potentials in excess of 600 volts and utilizing individual currents of 0.005 ampere or more, or having stored energy of 10 joules or more, shall be protected as follows:

1. All protective measures specified in Section VII.A shall apply. Equipment shall be labeled with an ASA sign, "DANGER -- HIGH VOLTAGE – KEEP OUT"
2. All access doors, covers, or removable shielding on any apparatus operating at this voltage shall be securely mounted and labeled to indicate the maximum voltage available
3. Access doors to power supplies and to termination enclosures shall be provided with appropriate interlocks. Such power supplies must be provided with permanent grounding.
4. One plainly labeled main switch or breaker that will de-energize all electrical power to the apparatus shall be provided. It shall be conveniently located adjacent to the experimental apparatus so that it can be actuated promptly in the event of an emergency.

VIII. OPERATIONS

A. General

Employees operating electrical equipment shall be informed by the appropriate supervisor of the potential hazards involved in using such equipment.

B. Portable Electrical Tools

1. All power cords, non double-insulated cord connected power tools, and other portable electrical equipment shall use proper grounding techniques. For the use of this policy, portable electrical equipment is defined as that capable of being readily moved from one place to another in normal use and connected to its source of current by means of a single cord and plug.

2. Hand-operated power tools (with the exception of electro-magnetically mounted drills) shall be connected to ground-fault interrupter (GFCI) devices for personnel shock protection.

IX. HIGH-VOLTAGE PLATFORMS (Voltages greater than 50 kV)

1. A conductive grounded shield of adequate height shall surround the high voltage platform.

2. There shall be an access door interlock that will automatically turn off the platform high-voltage power supply if the door is opened at other than an acceptable time.

3. Door access shall be interlocked through a grounding device before access is allowed. Interlock circuits shall be failsafe.

4. In order to get in, there shall first be no high voltage present on the platform ascertained in a way that can be visually verified.

5. A grounding stick, permanently attached to a permanently grounded cable shall be used as final check.

6. Suitable warning signs and safety instructions shall be posted on or near the access door.

7. Bleeder resistors shall be used if the circuit features will permit in order to discharge the stored energy.

X. CAPACITORS (with stored energy greater than 10 joules at 50 volts or greater)

1. Capacitors shall be enclosed in a secured, grounded metal enclosure.

2. Individual capacitors shall remain shorted during maintenance.

3. Bleeder resistors shall be used if the circuit timing features will permit.

4. Energy storage capacitor cases shall be mechanically secured and the case grounded if applicable.

5. Large capacitor banks having capacitors with flammable oil shall have adequate fire protection.

6. No PCB insulated capacitors shall be permitted.

7. In storage, capacitors shall be solidly shorted with a substantial copper conductor.

XI. HAZARDOUS GASES AND LIQUIDS

A. General

Areas in which hazardous flammable gases and flammable liquids are used shall be classed in accordance with Article 500 of the National Electric Code as Class I, Division 1 or 2, or nonhazardous. The electrical installations in these areas may use any or all industrially approved methods of safeguarding: elimination, explosion-proof equipment, purging, encapsulating, or intrinsically safe devices.

1. Procedures for the safe use of flammable gases are given in the Physics Division Safety Procedures for the Use of Flammable Gases with Detector Systems.

2. Gases such as hydrogen, methane, or butane require the use of explosion-proof equipment. Where available, UL listed equipment shall be used.

3. Ignition sources in hazardous areas shall be rendered safe wherever possible by removing them to a nonhazardous area.

4. Ignition sources in the form of arcing contacts, thermocouples, or other such measuring or control devices in hazardous areas may be made acceptable by making them intrinsically safe. The energy shall be so limited to 50 percent or less of the minimum required for ignition of the particular gas.

5. Control and other equipment in hazardous areas may be made acceptable by purging and pressurizing with dry air or nitrogen. If air is used, it shall be taken from a source impossible of contamination with a hazardous gas. Nitrogen shall be used wherever possible.

6. Small control or sensing devices shall be acceptable if made safe by encapsulation or hermetic sealing.

B. Approval and Inspection

Questions concerning the classification of hazardous areas and the interpretation of codes and practices shall be referred to the Physics Division Electrical Safety Committee.

Design and installation of electrical equipment in hazardous areas shall be subject to the approval and inspection of the Physics Division Electrical Safety Committee.

XII. MAGNETS AND INDUCTORS

This section refers to units that have stored energies over 10 joules, or currents greater than 50 amps, or which produce accessible magnetic fields in excess of 10 gauss.

A. Fringe Fields

Industrial hygiene states the suggested eight-hour/day whole-body exposure limit for dc or slowly-varying magnetic fields to be 100 gauss; however some cardiac pacemakers may be adversely affected by fields as low as 20 gauss. Pacemaker manufacturers recommend that persons with an implanted cardiac pacemaker not be exposed to dc fields greater than 10 gauss. When a magnetic field of 500 gauss or more is measured six inches outside the pole edge, a yellow line shall be placed on the floor with a suitable protection barrier at the 100 gauss contour or three feet from the magnet, whichever is farther.

B. Warning Signs

DOE has suggested that ANL post all areas where fields exist in excess of 10 gauss. An appropriate sign shall be posted conspicuously at the entrance to areas housing the field-producing equipment. These signs may be obtained from Industrial Hygiene (2-3310). If necessary, measurements are to be made to establish the 10 gauss boundary and this boundary suitably marked and posted.

C. Discharge

Free wheeling diodes, thyristors, or other automatic limiting devices shall be used to provide a discharge circuit for the stored energy when current is interrupted or a superconducting magnet quenches.

D. Connections

Particular attention should be given to connections in the current path of inductive circuits. Poor connections may cause destructive arcing. Exposed connections to the magnetic coils must be covered to prevent accidental contact. Dangerously high voltages may be generated when a super- conducting magnet quenches or the current is interrupted to the magnet.

E. Eddy Currents

Magnets or inductors with pulsed or varying fields should have a minimum of eddy current circuits. Where large eddy current circuits are unavoidable, units should be mechanically secure and able to dissipate any heat produced.

F. Cooling

Magnets or inductors that are liquid cooled shall be protected by thermal, pressure, or flow interlocks as necessary to prevent overheating and failure.

G. Construction

1. Insulation of suitable thickness or an additional shield shall be provided for the coils to prevent accidental damage to the conductors and subsequent fault conditions.

2. The location and design of enclosures shall be such that eddy currents, mechanical forces, or induced voltages due to the magnetic field will not produce any adverse effect under normal operating or fault conditions.

XIII. ELECTROMAGNETIC RADIATION

A. Warning

Signs stating the location and nature of an electromagnetic radiation hazard shall be prominently posted. Warning lights shall be used to indicate when the equipment is energized.

B. Monitoring

When equipment used may be capable of generating an electromagnetic radiation hazard, monitoring shall be provided to detect and measure the radiation. Where personnel may be exposed to hazardous levels, (as defined in Section XIII.C.2) monitoring equipment shall be interlocked to de-energize the generating equipment at a safe preset level.

C. Protection

1. X-ray producing equipment (high voltage vacuum tubes operating at greater than 15 kV), or any equipment that under operating or fault conditions could produce x-rays, shall be shielded from personnel. The Bldg. 203 Health Physics personnel (ext. 2-4138) shall be contacted to measure and evaluate the radiation hazard and the Physics Division Radiation Safety Committee shall assist in determining appropriate safety procedures to be followed.

2. Non-ionizing electromagnetic energy capable of producing a hazard shall be isolated in shielded enclosures. Transmission paths of microwave energy shall be enclosed or barricaded and well-marked with care taken that energy is not reflected out of this path. Industrial Hygiene personnel shall measure the radiation field of all equipment capable of generating an electromagnetic radiation field.

3. No person shall be exposed to an average power density greater than found in the latest edition of the Threshold Limit Values for Chemical Substances and Physical Agents, published by the American Conference of Governmental Industrial Hygienists (ACGIH)

Industrial Hygiene personnel (ext. 2-3310) shall be contacted for measurement of electromagnetic radiation levels and safety assistance before initial operation of any RF equipment capable of exceeding the above limits.

XIV. WORKING ON ENERGIZED CIRCUITS (WORKING HOT)

Electrical hot work is defined as "Working on or near exposed conducting parts that are or might become energized at 50V or more." The only work on energized electrical equipment that is authorized in the Physics Division is that which requires testing or measurement of energized circuits.

Working hot shall be considered a last resort after all other opportunities for establishing an electrically safe work condition have been exhausted. NFPA-70E permits testing and measurement of energized circuits by authorized qualified individuals without a formal hot work permit. All hot work performed in the Physics Division must be justified and must be performed in compliance with the requirements of NFPA-70E (2004). The only individuals who may perform work on energized circuits are: (1) qualified electrical workers authorized by the Physics Division Director, (2) those identified on the Physics Division Energized Electrical Test & Measurement Authorization document and (3) who are current in the ANL required training. Qualified persons are those persons deemed by Management to be sufficiently knowledgeable and competent to perform the specific task safely.

Specific Physics Division local interpretations and requirements for hot work approvals are described in this document.

A. General Policy and Guidelines

1. All energized electrical hot work requires formal review and approval via a completed "ANL Electrical Hot Work Permit."
2. All test & measurement activities other than for Lockout/Tagout (LOTO) require formal review and authorization via a completed "Physics Division Energized Electrical Test & Measurement Authorization" form. *Cautionary note: Voltage verification for LOTO purposes must be performed in compliance with NFPA-70E. Workers must be qualified and authorized. They must also wear the proper PPE.*
3. All Test & Measurement Authorization forms must identify the specific named person(s) authorized to perform the specified work.
4. Test & Measurement Authorization forms must be posted at the job site while the work is being performed, whether it is generalized, task specific, annual, or for one-time use.

B. Test & Measurement Authorization **Approvals and Responsibilities**

All Test & Measurement Authorization forms require a minimum of three separate signatures:

- Division Director (or designee) as appropriate
- Physics Division ESH Engineer
- Individual who performed the hazard analysis.

All Test & Measurement Authorizations shall name specific workers authorized to perform the work. Individuals shall sign the authorization form to confirm they have read and understand the contents, agree that the work can be performed safely, and will follow the conditions noted on the authorization form.

Division Director Responsibilities

- Appoints qualified electrical workers
- Approves conversion of task-specific one-time-use Test & Measurement Authorizations to extended-duration Test & Measurement Authorizations.

ESH Engineer Responsibilities

- Assures that the proper safety approval process has been followed.

Authorized Worker Responsibilities

- Complies with criteria on the Test & Measurement Authorization.
- Understands the safety envelope of work before starting, and stops work if conditions change beyond the original scope or safety envelope.
- Performs work according to established Physics Division safe working practices

XVI. LOCKOUT/TAGOUT

The ANL Lockout/Tagout Policy, as described in the ESH Manual, shall be followed at all times. Any deviation from this policy must be reviewed by the Physics Division Electrical Safety Committee. Note that all lockout/tagouts must be verified to insure they are effective. The verification step is considered hot work. While this hot work does not require a Hot Work Permit or a written procedure, it may only be performed by properly trained personnel wearing the proper PPE.

XVII. Tables

TABLE I [1/]

CURRENT RANGE AND EFFECT ON 150-lb PERSON

CURRENT	Physiological Phenomena	Feeling or Lethal Incidence
(60 Hz)		
< 1 mA	None	Imperceptible
1 mA	Perception Threshold	
1-3 mA		Mild Sensation
3-10 mA		Painful sensation
10 mA	Paralysis threshold of arms	Cannot release hand grip. If no grip, victim may be thrown clear. (May progress to higher current and be fatal.)
30 mA	Respiratory paralysis	Breathing stops. (Frequently fatal if not treated promptly
75 mA	Fibrillaton threshold 0.5 percent	Heart action is discoordinated. (Probably fatal.)
250 mA	Fibrillation threshold 99.5 percent (>5-s exposure.)	
4 A	Heart paralysis threshold. (No fibrillation.)	Heart stops during current passage, restarts normally on current interruption. (Usually not fatal from heart dysfunction.)
>5 A	Tissue-burning.	Not fatal unless vital organs are burned.

1/ R. H. Lee, "Electrical Safety in Industrial Plants," IEEE Transactions on Industry and General Applications, Vol. IGA-7, No. 1, January/February 1971.