If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match.
The on-screen version of the Collider-Accelerator Department Procedure is the Official Version.
Hard copies of all signed, official, C-A Operating Procedures are available by contacting the ESSHQ Procedures Coordinator, Bldg. 911A

C-A OPERATIONS PROCEDURES MANUAL

1.5 Electrical Safety Implementation Plan

Text Pages 2 through 10

Attachments

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: ***Signature on File***
Collider-Accelerator Department Chairman Date

J. Sandberg, P. Cirnigliaro

1.5 Electrical Safety Implementation Plan

1. Purpose

This procedure outlines plans that are followed in order to assure Electrical Safety. It covers formal requirements and describes techniques that shall be employed to increase the level of electrical safety awareness of all personnel who work on electrical equipment.

2. Responsibilities

2.1 The Chief Electrical Engineer, or his designee, shall spearhead the drive for Electrical Safety in the Department and is responsible for implementation of this procedure.

2.2 Group Leader - The C-A comprises several Electrical Engineering Groups as listed in the C-A Organization Chart. It shall be the responsibility of the Group Leader of each section to promote a safe environment within their group, and to see that all members of the group are trained and certified in the equipment for which they are responsible.

2.3 Supervisors - are responsible for maintaining safe working areas, for the training of all individuals in their group, for ascertaining that all individuals in their group have electrical safety training, if required, that is up-to-date, and for insuring all job assignments are evaluated using C-A-OPM 2.28, "C-A Procedure for Work Planning and Control for Operations". Supervisors shall authorize workers based upon the workers training, experience, and knowledge. This authorization shall be documented on Electrical Work Permit. Electrical Work Permit forms can be found on the SBMS Subject Area *Electrical Safety,* in the Forms Section, *Electrical Work Permits with Instructions.*

3. Prerequisites

All personnel working on any electrical system or equipment in the C-AD shall be familiar with BNL SBMS Electrical Safety, BNL SBMS Lockout/Tagout (LO/TO), C-A-OPM 1.5.3 "Procedure to Open or Close Breakers and Switches and Connecting/Disconnecting Plugs", C-A-OPM 2.36, "Lockout/Tagout for Control of Hazardous Energy". C-AD will provide on-site/work specific training to individuals in the electrical safety aspects of their job functions and assignments.

4. Precautions

All personnel shall ensure their own safety by following the standards, safety rules, and the training they receive. In general, all energy sources must be locked out and tagged. Working on or near energized sources, "Working Hot", is not permitted unless a valid working hot permit has been issued. Personnel shall utilize tools, instruments, equipment

(e.g., proper connectors and proper ac line cords), PPE, etc., that are safe and proper for the job. If any part of a job appears unsafe to any individual, it is their duty to discontinue work and inform the supervisor, manager, ESH Coordinator or the C-A ESHQ Division Head, of the unsafe condition.

5. Procedure

The following sections outline the procedure that shall be followed by all C-A personnel working on electrical equipment or apparatus connected to electrical energy sources.

5.1 Training

5.1.1 All C-A electrical personnel shall be trained in this procedure.

5.1.2 All employees involved in electrical work in the Department shall be trained in electrical safety, Lockout/Tagout, BNL SBMS on Subject Areas Electrical Safety and Lockout/Tagout (LOTO) and in the equipment they work on. Supervisors shall ensure that all personnel assigned to them (including outside visitors) shall have current verified training and that proper techniques and work planning are being followed in the work place.

5.1.3 All personnel who operate circuit breakers or disconnect switches rated <225 amp shall have current "Electrical Circuit Breaker and Switch Operation" (TQ-ELECTB50P) OR current Electrical Safety I (TQ-ELECSAF1) training.

5.1.4 All personnel who operate circuit breakers or disconnect switches rated ≥225 amps shall have current "Electrical Safety I" (TQ-ELECSAF1) training.

5.2 Safe Working Practices

5.2.1 All individuals shall follow good working practices. See SBMS Subject Area Electrical Safety, Electrical Safe Working Practices. Equipment shall be rated for the application and shall be protected for the use. Improper equipment, tools, cables, connectors, etc., shall NOT be used. Wherever possible, defective equipment or components shall be destroyed or discarded.

5.2.1.1 All new cables shall be clearly labeled at both ends to allow for easy and positive identification.

5.2.1.2 When installing new or disconnecting old cables, the cables shall be positively identified by testing to verify that the same cable is being handled at each end.

5.2.1.3 Disconnected cables shall be controlled as per C-A-OPM 1.5.1 "Disconnected Cable Policy".

5.2.1.4 Use of armored cable shall consider the safety guidance of Section 5.10.

5.2.1.5 Use of split-nut connectors (bug-nuts) for splicing stranded cables requires periodic visual inspection for corrosion and verification that the connection is still tight. Consider use of an IR camera to determine if the connection is heating more than expected, indicating a poor connection.

5.2.1.6 In accordance with DOE guidance, solenoid type voltage detectors shall not be used (i.e. Wiggins type).

5.2.1.6.1 Voltage measurements made at locations fed from high capacity sources subject to line voltage transients shall use properly rated Category III or IV meters. Meters not labeled as such shall be considered Category II. The most versatile meter is a category III & Category IV, since it may be used most everywhere and provides the most protection against injury.

5.2.1.6.2 All new general purchase voltmeters shall be Category III or IV meters, depending upon their intended use.

5.2.2 There is a specific OSHA requirement for all electrical equipment to be "Nationally-Recognized Testing Laboratory" (NRTL) approved/listed/certified.

5.2.2.1 Per OSHA: "The NRTL determines that specific equipment and materials ("products") meet consensus-based standards of safety to provide the assurance, required by OSHA, that these products are safe for use in the U.S. workplace."

It is the purchaser's responsibility to ensure that the electrical equipment (any device connected to a source of electrical power; i.e. plugs into an outlet), is NRTL approved. (Additionally, any battery operated device operating at 50 volts or greater is to be considered electrical equipment). This applies to credit card purchases AND web requisitions. I an item is NOT NRTL approved, it CANNOT be purchased with a credit card; a web requisition must be used AND QA requirement 4.40 must be selected from the BNL-QA-101 drop down to ensure the proper requirements are flowed down to the supplier (see: https://sbms.bnl.gov/sbmsearch/subjarea/10/2d01e011.doc)

One way to determine if an item is NRTL approved is to look for a specific certification mark (although according to OSHA, this is not a 100% guarantee) see: http://www.osha.gov/dts/otpca/nrtl/nrtlmrk.html

The best was is to ask the manufacturer if the item is NRTL approved (although this is not always practical). Please Note: The European CE mark is NOT an approved NRTL certification mark. See: http://www.osha.gov/dts/otpca/nrtl/NRTLarticle.html ; specifically "CE" Mark and Foreign Testing Organizations.

If you purchase, receive or identify an existing piece of electrical equipment that is NOT NRTL approved, the process to follow is outlined in The SBMS Subject Area Electrical Safety, Review and Approval of Electrical Equipment and Installations.

For a current list of NRTL's see: http://www.osha.gov/dts/otpca/nrtl/nrtllist.html.

For a good overall summary on the OSHA requirement for NRTL approval, see: http://www.osha.gov/dts/otpca/nrtl/NRTLarticle.html.

For additional guidance, you can contact the C-AD Chief Electrical Engineer.

5.2.3 The most important aspect of electrical safety is lockout/tagout, which guarantees that ALL energy sources for a piece of equipment have been secured before work shall begin. All equipment shall be designed, constructed, or procured so that LOTO can be accomplished. All personnel working on electrical equipment shall strictly follow the above guidelines and the training that they receive.

5.2.4 It is the responsibility of the project engineer/physicist, the group leader, and the Chief EE to ensure all work that involves installing, moving, or adding electrical power must include the labeling of circuit breakers and/or disconnect switches and cables as part of the work package.

5.2.4.1 If equipment is powered from a remote breaker or disconnect switch, (i.e. another building or a location judged to be confusing to operating personnel), the equipment itself shall be labeled with information describing the location of its supply breaker/disconnect switch.

5.2.5 The work planner shall evaluate all jobs against criteria in C-A-OPM 2.28, "C-A Procedure for Work Planning and Control for Operations".

5.3 Safety Inspections

5.3.1 It shall be the responsibility of the sectional Group Leader and the area supervisor to routinely inspect the physical areas under their control and the major equipment designed and/or maintained by their Group.

5.3.2 The C-A Safety Inspection Committee shall conduct safety inspections of all areas on a regular basis. The C-A Chief Electrical Engineer shall assign at least one member to this committee who will accompany the inspection tours. This member shall aid in the inspection of electrical equipment. A list of findings from the inspections shall be sent to the C-A Chief Electrical Engineer by the Committee Head or designee. If an item or finding requires an electrical engineering review or certification then a memo shall be sent to the C-A Chief Electrical Engineer by the Committee Head requesting a review.

5.4 Department Design Reviews

As defined by the C-A criteria, C-A-OPM 13.6.1, Preparation & Issuance of Engineering Drawing/Specifications, all new projects, major modifications to existing equipment, or procurements generated by such a project, shall undergo design reviews. As part of this review, electrical safety criteria shall be covered to assure adherence to OSHA requirements described in BNL SBMS Subject Areas Electrical Safety and Lockout/Tagout (LOTO). This is not in lieu of but in addition to the review of all safety issues covered by the C-A Accelerator System Safety Review Committee or the Experiment Safety Review Committee.

It is the responsibility of the project engineer/physicist, the Group Leader and the Chief EE to ensure that all changes are safe.

New systems/equipment shall be documented on C-A engineering drawings. All design changes to existing systems shall be recorded on C-A Engineer Change Notice (ECN's).

5.5 Testing Areas

All C-A high-power equipment shall undergo testing with proper barriers in place and with adequate safety zones for the equipment as well as the load. Safety interlocks and crash buttons shall be employed where appropriate.

5.6 Unusual Event Investigation

A system exists for the formal investigation of Reportable Occurrences. There are, however, incidents or situations that do not meet the criteria for a formal investigation or for which Department or Divisional Management request additional information. These events will be investigated by the Chief EE, or designee, for their safety related content.

5.7 Electrical Safety Procedures

Lockout/Tagout procedures shall be used whenever possible when maintenance or construction is performed on equipment that has the potential for energy release.

Electrical safety-related work practices shall comply with the BNL SBMS Subject Area on Electrical Safety, which is equal to or exceeds the requirements of NFPA 70E, Standard for Electrical Safety in the Workplace. This includes requirements for PPE.

PPE requirements for operating breakers, switches, and plugs are specified in detail in C-A-OPM 1.5.3.

Special PPE guidelines for testing on line-cord equipment is given by the BNL Electrical Safety Committee in Attachment 8.7.

The use of non-contact voltage detectors, sometimes called Tic Tracers, is not an acceptable method for doing a zero energy check on electrical systems. See Attachment 8.8.

Although it is Department policy to use LOTO when working on electrical equipment, there are circumstances that require working on energized equipment. To meet the requirements of Electrical Safety:

5.7.1 The Department requires that any supervisor, who ascertains the need for not applying LOTO to perform certain tasks, must write a procedure and a permit following the subject area on Electrical Safety. The supervisor may consult with the ESSHQ Division for assistance.

5.7.2 Electrical Work Permits:

Generic electrical work permits can be written for the electrical hazard present. These permits allow personnel to test, check, verify, and trouble shoot equipment under very controlled conditions. Permits describe the circuit and equipment to be worked on, justification for energized work, safe work practices, shock hazard analysis and protection boundary, flash hazard analysis and protection boundary, personal protective equipment (PPE) required, means employed to restrict access to unqualified persons, evidence of pre-job briefing and any post job feedback, and approving signatures. The Electrical Work Permit is to be used when live parts cannot be placed in an electrically-safe condition to perform the work.

5.7.2.1 The C-A Department Chair has identified the following circuits as critical circuits, where de-energizing the circuits could create a greater hazard then working "hot". Only these circuits can be worked on using an electrical work permit for manipulating while energized:

C-A Access Security System
C-A Fire Protection System
C-A Ring, experimental building and Cave Ventilation Controls System
C-A and Experimental Areas, Cryogenic Controls Systems and Monitors Uninterruptible Power Supply System Modules for Control Room (enables communication), Security, Ventilation, and Fire Protection Control Systems
C-A Control Room Lighting Systems
C-A Main Magnet Power Supply Battery Control System
Uninterruptible Power Supply Battery Sections

5.7.3 Conditions

Training must be relative to the task performed (i.e. personnel must be trained in the permit that was written for the job.).

5.7.4 The permit will be filled out, signed by the Supervisor, and presented to the Chief EE and or ESSHQ Division Head for approval to proceed with the work.

5.7.5 Copies of the approved permits are to be maintained by the ESSHQ Division.

5.7.6 Personnel performing the work must have a copy of the permit in the work area.

5.8 Temporary Wiring

5.8.1 For programmatic reasons, temporary wiring may be used with the approval of the C-A Chief Electrical Engineer, F&ES Section Head, or the Power Distribution Group Leader.

5.8.2 This approval may be up to 6 months

5.8.3 As soon as possible, the approver shall ask the C-A QA Group to enter the requirement to replace the temporary wiring with permanent wiring or remove the temporary wiring within 6 months of the date of its installation into the C-A Family ATS. The approver shall be the individual responsible to ensure that this is done within 6 months.

5.9 Use of Armored Cable in contact with Non-Armored Cable/Abandoned Cable in Trays.

Strands of the cable armor can be broken and sharp. When installing armored cable (such as RG219) over existing unarmored cable it can cut into the insulating jacket of this cable.

5.9.1 Armored cable that can be broken and sharp shall be separated from unarmored cable when possible. If not possible, the armored cable should be purchased with an outer insulating sheath.

5.9.2 Work planning shall take into account that armored cable may have abraded the insulation of existing adjacent cables.

5.9.3 All cable tray work shall include provisions for removing unused cables from the tray.

5.9.3.1 Written permission from the Chief EE or delegate shall be obtained if unused cables are to remain in trays.

5.9.3.2 If permitted, the unused, disconnected cables shall comply with C-A OPM 1.5.1, Disconnected Cable Policy.

6. Documentation

6.1 Safety Inspection Committee Surveys - The copies of the safety inspection reports performed by the Department Safety Inspection Committee will be made available to the Group Leader and Supervisor of each of the Engineering Groups.

6.2 Training Records – The C-A Training and Procedures Manager shall maintain all training records.

6.3 Specific equipment training lists – The C-A Supervisors shall maintain lists of all their assigned personnel and the equipment for which they have been trained (OJT checklists).

6.4 Maintenance and Operating Procedures - All new equipment and major modifications to existing equipment shall be fully covered by maintenance and operating procedures. Each area shall keep a current list of all applicable procedures for each of their systems.

6.5 Electrical Safety Procedures and Permits - The Training and Procedures Manager shall maintain a file/data base of personnel trained in Electrical Safety Procedures.

6.6 The C-A Chief Electrical Engineer, or designee, shall maintain a file of issued energized circuit work.

7. References

7.1 C-A-OPM 2.28 "C-A Procedure for Work Planning and Control for Operations".

7.2 BNL SBMS Subject Area – Electrical Safety.

7.3 BNL SBMS Subject Area – Lockout/Tagout (LOTO).

7.4 OSHA 29 CFR 1910.

7.5 C-A-OPM Section 13.

7.6 C-A-OPM 1.5.1, Disconnected Cable Policy.

7.7 J. Sandberg, Use of "Wiggins" Type Solenoid Voltage Detectors, December 14, 2004.

7.8 C-A-OPM 1.5.3, Procedure to Open or Close Breakers and Switches and Connecting/Disconnecting Plugs.

7.9 C-A-OPM 2.36 "Lock and Tag Program for Control of Hazardous Energy".

7.10 National Fire Protection Association (NFPA) 70, "National Electrical Code," (2005).

7.11 NFPA 70E, "Standard for Electrical Safety in the Workplace," (2004).

8. Attachments

8.1 J. Sandberg, Use of Armored Cable in Contact with Non-Armored Cable/Abandoned Cable in Tray, November 16, 2004.

8.2 J. Curtiss, LESC, PPE for Testing on Line-Cord Equipment.

8.3 J. Sandberg, Use of Non-Contact Voltage Detectors, December 22, 2005.

Attachment 8.6

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

TO: C-AD Electrical Staff

FROM: J. Sandberg

SUBJECT: Use of Armored Cable in Contact with Non-Armored Cable / Abandoned Cable in Tray

DATE: November 16, 2004

During some recent AGS upgrades a piece of armored RG219 was moved and electrical arcing was observed in its corresponding cable tray. Investigation showed that strands of the armor were broken and very sharp. During installation the RG 219 was pulled over existing unarmored cable and it cut into the insulating jacket of some of this cable. The observed arcing was from a 120 V ac wire that had been abraded by the armor of the RG 219. In this case the 120 V ac wire had been abandoned in the cable tray and was not in use.

Caution must be taken in all future installations to avoid this problem. Armored cable of this type must be separated from unarmored cable. If this is not possible the cable should be purchased with an outer insulating sheath. This concern must be addressed in all future design reviews and safety evaluations.

No problems were found during an inspection of similar installations. Although this is encouraging, it was not an exhaustive inspection. All future work planning must take into account the possibility that this type of armored cable may have abraded the insulation of adjacent cables.

All future cable tray jobs shall include provisions for removing unused cables from the tray. Cost estimates shall take this into account, including the disposal of the cable. Written permission from the Chief EE or his delegate shall be required if unused cables are to be allowed to remain in the tray. The default condition shall be the removal of all such cables.

Attachment 8.7

PPE for Testing on Line-Cord Equipment

The Laboratory Electrical Safety Committee provides the following information regarding work on equipment powered through a 120-volt line-cord.

BNL requires that Personal Protective Equipment (PPE) be used during test and adjustment of electrical equipment operating over 50 volts, to protect against the two hazards of electric shock and arc flash. Selection of appropriate PPE may be determined by using the two tables in the PPE Manual, available on the SBMS web site.

Protection against shock hazards

The first table in the PPE manual, *Table 130.7(C)(9)(a) Hazard/Risk Category Classifications*, requires use of voltage-rated gloves and leather glove protectors during test and adjustment of equipment operating at 120 volts, whenever a handheld probe will be used to contact an energized part.

Use of gloves may be avoided by unplugging the equipment, temporarily connecting the test meters while the circuit is de-energized, plugging the equipment in and turning it on, making tests and adjustments, turning off the equipment, and removing the test meters.

Protection against arc flash hazards

Arc flash is the other hazard associated with testing energized equipment. The first table in the PPE manual identified work on energized 120-volt parts, including voltage testing, as arc flash Hazard/Risk Category 1 task. Protection against the effects of an arc flash may be determined by referring to the second table in the PPE manual, *Table 130.7(C)(10) Protective Clothing and Personal Protective Equipment (PPE) Matrix*. Such work is Hazard/Risk Category 1 and requires a long-sleeve flame-retardant shirt (with a minimum Arc Rating of 4 cal/cm^2), long denim pants, safety glasses, and a hard hat.

Reduced PPE requirements may be used if the Hazard/Risk Category can be reduced from Category 1 to Category 0. A footnote to the first table allows this reduction for conditions where less than 10 kA short circuit current is available (for a short circuit clearing time of two line cycles). If the equipment under test is connected to a 120-volt receptacle by an AWG 16 or 14 line cord at least three feet long, or AWG 12 at least six feet long, then the maximum fault current that can be delivered at the equipment end of the cord is less than 10 kA.

The resulting reduction in Hazard/Risk to Category 0 by this analysis requires using only a long-sleeve shirt and long pants both of natural-fiber, and safety glasses. The reduced PPE requirement eliminating the hard hat and backing off requirements for shirt and pants may make testing and troubleshooting of line-cord equipment more convenient. If the equipment has a shorter cord, then an extension cord may be used in conjunction with the equipment cord to provide the required circuit length.

February 2005
For the Laboratory Electrical Safety Committee,

Joseph A. Curtiss, P.E.
Laboratory Electrical Safety Officer

Attachment 8.8

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

TO: C-AD Personnel

FROM: J. Sandberg

SUBJECT: Use of Non-Contact voltage detectors

DATE: December 22, 2005

The use of non-contact voltage detectors, sometimes called Tic Tracers, is not an acceptable method for doing a zero energy check on electrical systems. While such devices may be UL approved and may be useful for preliminary testing of circuitry, the Department of Energy disallows their use in verifying circuits for the purposes of Lock Out / Tag Out (LOTO).

There are several significant limitations to these devices:

1) They cannot measure DC voltages. There are many sources of dangerously high DC voltages at C-AD. These include, power converters, Uninterruptible Power Supply battery banks, station batteries, and capacitive discharge devices.

2) They cannot measure voltages present on shielded cables.

3) They may not measure voltages on tightly coupled wiring such as twisted pair.

4) There have been many false readings using such device reported throughout the DOE complex.

One of the fundamental principles of electrical safety is to consider all electrical conductors energized unless properly LOTO'd. Proper LOTO requires that there be an ***acceptable*** zero energy check done on the conductors in question. Always check for AC, as well as DC voltage, when doing zero energy check.

Three Non-Contact Voltage Detectors commonly found at C-AD