

BDDP-EE-9916
Rev. A

ACCELERATOR DIVISION DEPARTMENTAL PROCEDURE

ELECTRICAL/ELECTRONIC SUPPORT DEPARTMENT

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EQUIPMENT SPECIFIC LOCKOUT/TAGOUT PROCEDURE
for the
NuMI TARGET HALL FOCUSING HORN POWER SUPPLY

PREPARED BY _____ DATE September 8, 2004
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APPROVED BY _____ DATE _____
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REVIEW AND CONCURRENCE RECORD

REVIEWED BY _____ DATE _____
Howie Pfeffer

1.0 PURPOSE AND SCOPE

The purpose of this Accelerator Division Departmental Procedure (ADDP) is to outline and detail the conduct of LOCKOUT/TAGOUT (LOTO) for the maintenance of the NuMI Production Horn Power Supply. The power supply system consists of three elements; two 240 kW PEI direct current charging sources and a separate enclosure housing banks of capacitors that could retain a lethal level of stored energy.

2.0 PERFORMANCE OF MAINTENANCE ACTIVITIES

The Production Horn Power Supply system is installed in the Target Hall Support Room (THSR) of the NuMI underground cavern for beamline operation. This procedure shall be followed when accessing any exposed bus in the Target Hall. Exposed bus also exists within the fenced area adjacent to the capacitor bank and this procedure shall also be followed before entrance into that area.

3.0 AUTHORIZED PERSONNEL

An Accelerator Division employee is authorized to perform this LOTO procedure if he/she has the necessary knowledge and current training in electrical safety, has read and understands this LOTO procedure, possesses the requisite knowledge with respect to high power electronic equipment, the configuration of the horn load and the conductors connecting them.

A list of E/E Support Department personnel authorized to perform this LOTO procedure and perform maintenance on the NuMI THSR Horn Power Supply shall be kept by the Accelerator Division E/E Support Group Department Head.

4.0 THE NECESSITY OF WRITTEN LOTO PROCEDURE

Written LOTO procedures apply to the NuMI THSR Horn Power Supply system for three reasons. First, the capacitor bank has the ability to retain lethal levels of stored energy. Second, to de-energize the PEI charging supplies will require two sources of energy to be locked out. Finally, the maintenance and testing after repair may expose personnel to electrical hazards in the area of exposed stripline and horn connections.

5.0 THE STEPS OF LOCKOUT/TAGOUT PRIOR TO MAINTAINANCE ACTIVITY

The authorized employee shall perform the following steps prior to performance of any maintenance activity internal to the PEI, the capacitor bank enclosure, or the fenced area around the stripline, or horns. Maintenance to the modules of the control section of the PEI or system controls can be performed at any time as there are no exposed hazardous voltages.

- 5.1 **Prepare:** The authorized employee shall understand the hazards involved and how to control them. If you do not have this knowledge, you are not qualified to perform this LOTO procedure. **Safety Glasses shall be worn at all times while performing this procedure. The two-man rule shall apply at all times maintenance work is performed on this equipment**

This equipment has large, high voltage energy storage capacitors that may be charged to as much as 1,000 volts, containing up to 112 kilo-Joules of stored energy. The capacitor bank normally delivers 205 kilo-Amps to its load and is capable of delivering a very high level of fault current into a low impedance short circuit.

- 5.2 **Notify:** The authorized employee should, as necessary, notify affected area personnel of the LOTO maintenance activity. Affected personnel includes those who might normally use the equipment or would be affected by the unavailability of the equipment. It may be necessary to notify the Crew Chief in the Main Control Room (Ext. 3721), particularly if maintenance work is to be done to the water cooling system.
- 5.3 **Shutdown:** The authorized employee shall shut down the power supply system by pushing the DC OFF button on the front panel of **both** PEI charging sources. Open the circuit breaker on the front panel of each PEI by moving the handle from the On position to the Off position.

Note: Pushing the DC OFF button will only turn off the DC output of each respective PEI supply.

- 5.4 **Isolate and Verify:** The authorized employee shall isolate and verify the PEIs have been disconnected from their energy source by moving the safety switch handle in power panel DS-NuMI HORN P.S. to the OFF position. Verify that the 480 V_{AC} power has been shut off by observing the position of the three switch blades as seen through the window on the front panel of the safety switch enclosure.

- If maintenance activity is to be performed on the PEI(s), also open circuit breaker #2 for PEI-A and circuit breaker #4 for PEI-B in power panel PP-MI65A-5-A-1 to isolate the 120 V_{AC} power to the supplies. Verify that the 120 V_{AC} has been turned off by observing the PEI front panel indicator lights before and after opening the circuit breaker.

Note: All 120 V_{AC} wiring within the capacitor bank enclosure is guarded and protected by utility boxes, terminal strip covers, etc. 120 V_{AC} power to the capacitor bank enclosure is controlled by circuit breaker #6 in power panel PP-MI65A-5-A1. No 480 V_{AC} power exists within the capacitor bank enclosure.

- 5.5 **Lock and Tag Out:** The authorized employee shall lock and tag the energy isolating devices by applying locks and tags to the appropriate circuit breaker(s)

and safety switch.

- 5.6 **Relief of stored energy:** The capacitor bank circuitry includes redundant shorting relays, with respective resistors, to automatically discharge stored energy in the four groups of capacitors upon removal of the permit key from the controls rack. The maximum discharge time constant for each capacitor bank section is 18 seconds. Five time constants for full discharge is 90 seconds. Proceed with caution while performing the following steps.

When working on or near any exposed stripline bus in either the THSR or the Target Hall follow this procedure to the completion of this section.

- Obtain the key for the capacitor bank enclosure doors from the front panel of the control electronics equipment rack.
- Open the center bay doors on one side of the capacitor bank enclosure and inspect the position of the shorting relay. The relay high voltage contacts should be closed. Visually inspect the integrity and wiring of the 12 discharge resistors located on the ceiling.
- Close and re-lock the doors.
- Open the center bay doors on the opposite side of the capacitor bank enclosure and inspect the position of the shorting relay. The relay high voltage contacts should be closed. Visually inspect the integrity and wiring of the 12 discharge resistors located on the ceiling.
- Using the resistive ground stick, located on the door, make contact with the ground stick test point located within the enclosure center bay at top-center just inside the door opening. Listen for a pulsed audio tone for verification that the resistive ground stick is in proper working condition. If a continuous tone (shorted condition) or no tone (open condition) is the result, do not continue with this procedure but seek help from a person knowledgeable of the equipment.
- Using the resistive ground stick, contact the lower portion (cathode) of each SCR heatsink assembly, six locations in all. If a spark occurs while performing this step do not proceed; close and lock all enclosure doors and seek help from a person knowledgeable of the equipment.
- With the use of the hard ground stick, tested for continuity, contact the same locations one by one. While holding the ground stick in place at each respective SCR position, attach the grounding clip-lead to the SCR assembly grounding point. Repeat this procedure for all six SCR positions on this side of the enclosure.

- Verify that the six clip lead placements are secure. Close and re-lock the doors.
- Return to the first side of the enclosure and open the center bay doors.
- Using the resistive ground stick, located on the door, make contact with the ground stick test point located within the enclosure center bay at top-center just inside the door opening. Listen for a pulsed audio tone for verification that the resistive ground stick is in proper working condition. If a continuous tone (shorted condition) or no tone (open condition) is the result, do not continue with this procedure but seek help from a person knowledgeable of the equipment.
- Use the resistive ground stick to contact the lower portion (cathode) of each SCR heatsink assembly, six locations in all. If a spark occurs while performing this step do not proceed; close and lock all enclosure doors and seek help from a person knowledgeable of the equipment.
- With the use of the hard ground stick, tested for continuity, contact the same locations, one by one. While holding the ground stick in place at each respective SCR position, attach the grounding clip-lead to the SCR assembly grounding point. Repeat this procedure for all six SCR positions on this side of the enclosure.
- Verify that the six clip lead placements are secure. Close and re-lock the doors.
- Install an instruction tag on the 480 V_{AC} safety switch, power panel DS-NuMI HORN P.S., that states: "**Do not operate - Capacitors grounded.**"

It is now safe to enter the fenced area around the stripline or the Target Hall to service the horns or striplines, or to service the PEI supplies. If the capacitor bank is configured with all capacitors in parallel (wide pulse configuration) it is also safe to perform maintenance on the capacitor bank. **However, if work or maintenance activity is to be performed on any portion of the capacitor bank and the capacitor bank is configured with series pairs of capacitors (narrow pulse configuration, 2.6ms), the remaining steps of this procedure *must* be completed before the work activity is started.**

- 5.7
- Verify by observation of the grounding clip-lead placements in the center bays on both sides of the enclosure that the above steps have been performed before proceeding with the following steps.
 - Open the doors to one quadrant of the capacitor bank. Using the resistive ground stick, tested for continuity, make contact with the “Z” link on each pair of capacitors in the three rows of that quadrant. If a spark is observed at a contact point, maintain contact for a time period of no less than 15 seconds.

Note: The time constant for discharge with the resistive ground stick is 3 seconds. Allow five time constants, 15 seconds, for complete discharge. The bleeder resistor mounted to each capacitor has a time constant of 12 minutes and serves to prevent the build-up of relaxation charge (from dielectric absorption) once the capacitors have been discharged in the above procedural step. Full discharge by bleeder resistors alone will take one hour.

- Using the hard ground stick, tested for continuity, make contact with the “Z” link on each pair of capacitors in the three rows of the same quadrant.
- Move to the next quadrant and repeat the two previous steps, first with the resistive ground stick and then the hard ground stick to relieve any stored energy in that quadrant.
- In a similar manner, ground the remaining two quadrants to relieve any stored energy from the capacitors.
- Close and lock the enclosure doors in all areas except where the maintenance activity is to be performed.

Verify: Before performing maintenance on any portion of the capacitor bank, verify with the use of a voltmeter that no relaxation charge has accumulated on any of the capacitors.

The equipment is now Locked Out and Tagged Out. Service or maintenance activity in the capacitor bank or PEI charging supplies may now begin.

6.0 SHIFT AND PERSONNEL CHANGES

A lead authorized employee shall ensure that Lockout/Tagout procedures are followed when the PEI and capacitor bank enclosure are locked out over a shift or personnel change. This same lead authorized employee shall ensure:

- that no unauthorized lock and tag removals have taken place.
- an orderly exchange of locks and tags from off-going to on-coming employees.
- an orderly transfer of responsibility and information about the equipment status from the off-going to on-going shift.
- if the equipment is left unattended with any doors removed, both circuit breakers will be Locked and Tagged out and all twelve grounding clip leads will be securely attached to the twelve respective capacitor/SCR busses in the center bay of the enclosure after following proper grounding procedures.

7.0 THE FIVE STEPS FOR RETURN TO SERVICE

The authorized employee must perform the following five steps prior to returning the equipment to service after maintenance activity.

7.1 **Check Equipment:** Check the equipment and the immediate area around it to ensure that nonessential items and tools are cleared and that the equipment is ready for safe operation.

- Check high current components and all high current connections for tightness and integrity.
- Check capacitor bus insulation for integrity.
- Good housekeeping practices shall be followed to prevent compromising high voltage bus insulation. Any debris must be removed by the use of a vacuum cleaner, never by blowing or by the use of compressed air.
- Remove any remaining grounds from the twelve capacitor/SCR busses before returning the equipment to service. Park the grounding clip-leads at their respective anchor points adjacent to each SCR.
- Stow the resistive and hard-ground sticks in their respective holders on the enclosure center bay doors.
- Close and lock all doors on the capacitor enclosure. Close and secure the gates to the fenced area. Return enclosure door key to the captured key interlock switch in the controls rack. Close and latch/lock all doors and panels on the PEI charging supply.

7.2 **Check Work Area:** Check the work area to ensure that all employees are safely positioned or removed from the area as necessary and/or appropriate. Check the stripline in the THSR and/or the Target Hall to be sure no tools, equipment or grounding leads have been left on any conductors.

7.3 **Verify:** Verify that all controls are in the OFF position.

7.4 **Remove Padlocks and Tags and re-energize:** The authorized employee who installed the locks and tags shall remove them and reconnect the PEI charging supply to the energy sources from which it was isolated. Remove "Do Not Operate - Capacitors Grounded" tag.

7.5 **Notify:** The authorized employee should, as necessary, notify affected area personnel of the completion of maintenance and LOTO activity. If the Crew Chief in the Main

Control Room was notified prior to the activity, he/she should be notified of the completion of the activity.

This completes the requirements for returning the power supply system to service.

8.0 PROCEDURE TRAINING REQUIREMENTS

Authorized employees are required to have had LOTO training (Level 1 and Level 2), and have read and understood this LOTO procedure.

Electrical/Electronic Department Personnel using this procedure shall be trained on the job. After reviewing this document, the employee shall perform these steps accompanied by an employee with previous experience. The authorized employee shall then complete an "Accelerator Division Electrical/Electronic Department Procedures Review Form" and turn it in to the department administrative assistant.

Personnel from other departments shall be trained according to the requirements of their department.

9.0 PROCEDURE DISTRIBUTION

Additional controlled copies shall be distributed as deemed appropriate by the Electrical/Electronic Support Group Department Head.

Distribution of controlled copies shall be in accordance with ADAP-01-0001, Accelerator Division Procedure Requirements, Section 3.7.3.

Attachment

Shut-down Check-list - NuMI Production Horn Power Supply

Horn or Stripline

- O Both PEIs, DC-OFF, breakers opened.
- O 480 V_{AC} Safety Switch OFF – Locked – verify 480 V_{AC} power OFF

- O Open – observe shorting relay, resistors – lock center bay cap. bank doors first side.
- O Open center bay cap. bank doors on second side - Observe shorting relay, resistors.
- O Test resistive ground stick.
- O Ground capacitor/SCR buses.
- O Test hard-ground stick
- O Ground capacitor/SCR buses, attach grounding clip-leads.
- O Verify clip-lead placement - Close and lock doors.
- O Re-enter first side.
- O Test resistive ground stick.
- O Ground capacitor/SCR busses.
- O Test hard-ground stick.
- O Ground capacitor/SCR buses, attach grounding clip-leads.
- O Verify clip-lead placement - close and lock doors.
- O Place “Capacitors Grounded” tag on 480 Vac Safety Switch.

Capacitor bank – PEI access – above steps plus the following:

- O If working on PEI(s), 120 V_{AC} breaker OFF – Locked.
- O Test ground sticks, ground capacitors at “Z” link – 1st quadrant.
- O Test ground sticks, ground capacitors at “Z” link – 2nd quadrant.
- O Test ground sticks, ground capacitors at “Z” link – 3rd quadrant.
- O Test ground sticks, ground capacitors at “Z” link – 4th quadrant.
- O Verify capacitors are discharged with voltmeter.
- O Close doors, except as needed for maintenance.

Attachment II

Start-up Check-list - NuMI Production Horn Power Supply

Starting up from capacitor bank and/or PEI maintenance activity;

- O Check high current components for integrity, tightness.
- O Check bus insulation for integrity, cleanliness.

Starting up from Horn and/or Stripline maintenance activity;

- O Remove all grounds
- O Stow ground sticks
- O Close and lock all doors
- O Clear area and advise area personnel
- O All controls in OFF position
- O Remove locks/tags from breakers and safety switch.
- O Notify Control Room personnel as necessary
- O Energize system per current Operation Procedures.