

BEAMS DIVISION DEPARTMENTAL PROCEDURE  
ELECTRICAL/ELECTRONIC SUPPORT DEPARTMENT  
BDDP-EE-9916  
EQUIPMENT SPECIFIC LOCKOUT/TAGOUT PROCEDURE  
for NuMI PRODUCTION HORN POWER SUPPLY

PREPARED BY \_\_\_\_\_ DATE July 23, 2001  
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APPROVED BY \_\_\_\_\_ DATE \_\_\_\_\_  
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REVIEW AND CONCURRENCE RECORD

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## 1.0 PURPOSE AND SCOPE

The purpose of this Beams Division Departmental Procedure (BDDP) is to outline and detail the conduct of LOCKOUT/TAGOUT (LOTO) for the maintenance or transport of the NuMI Production Horn Power Supply while operating in MI-8. The power supply system consists of three elements, two 240 kW PEI 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 will ultimately be installed into the NuMI underground cavern for beamline operation. In the interim, it will be operated for the purposes of testing the capacitor bank and controls while at the same time testing the prototype horn and stripline at full power. The equipment is located in the south end MI-8 service building of the Main Injector accelerator.

One item of maintenance activity, in addition to repair and calibration, will be relevant to the preparation for transport of the capacitor bank enclosure from one location to another. Portability is accommodated by the use of an overhead crane for lifting via lifting hooks installed atop the capacitor bank enclosure. As part of the re-location process, the output stripline and the electrical cabling from the PEI charging source must be disconnected. Disconnecting these items will require entrance to the high voltage section of the equipment, thus Lockout/Tagout procedures must be followed. An approved crane operator working in concert with the authorized employee shall be the means for moving the unit between locations. The authorized employee and the licensed crane operator may be the same person.

## 3.0 AUTHORIZED PERSONNEL

A Beams 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 and the configuration of the horn load.

In the event that work not of an electrical nature is to be performed within the PEIs or capacitor bank enclosure by persons not knowledgeable of the electrical hazards therein, the lead authorized employee defined in the above paragraph shall perform the Lockout/Tagout steps and shall be the first to place his/her lock on the disconnects during lockout and the last to remove his/her locks when work is completed.

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

#### 4.0 THE NECESSITY OF WRITTEN LOTO PROCEDURE

Written LOTO procedures apply to the NuMI Production 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, dummy load, and horn. 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, with a maximum of 120 kilo-Joules of stored energy. The capacitor bank is capable of delivering high fault currents into a low impedance short.

- 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.

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

- 5.4 **Isolate:** The authorized employee shall isolate the equipment from its energy

sources.

- Open breaker #17 in power panel DHP-MI8-1 to isolate the 480 V<sub>AC</sub> power from the PEI supplies. Verify that the 480 V<sub>AC</sub> power is off by observing the front panel AC voltmeter before and after opening the circuit breaker. Rotate the voltmeter selector switch through all three phases. Note: The front panel disconnect switch must be in the ON position for the voltmeter to indicate.
- If maintenance activity is to be performed on the PEI(s), open circuit breaker #13 in power panel PP-MI8-1A-5-A1 to isolate the 120 V<sub>AC</sub> power to the supplies. Verify the 120 V<sub>AC</sub> has been turned off by observing the front panel indicator lights before and after opening the circuit breaker.

Note: All 120 V<sub>AC</sub> wiring within the capacitor bank enclosure is guarded and protected by utility boxes, terminal strip covers, etc. 120 V<sub>AC</sub> power to the capacitor bank enclosure is controlled by circuit breaker #17 in power panel PP-MI8-1A-5-A1. No 480 V<sub>AC</sub> power exists within the capacitor bank enclosure.

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

**Do not enter the fenced in (caged) area around the horn and stripline until this procedure is completed.**

- 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. 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. 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.

- 5.7
- Install an instruction tag on the 480 V<sub>AC</sub> circuit breaker, breaker #17 in power panel DHP-MI8-1, that states: **"Do not operate - Capacitors grounded."**

It is now safe to enter the fenced areas to service the horn, stripline, and dummy load; 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.

- 5.8
- 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), the remaining steps of this procedure *must* be completed before the work activity is started.**

- 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 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 lock the gates to the fenced area. Return enclosure/cage 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.
- 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 the steps accompanied by an employee with previous experience. The authorized employee shall then complete a "Beams Division Electrical/Electronic Department Procedures Review Form" and turn it in to the department secretary.

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 Department Head.

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

## **Attachment I**

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

### **Horn – Stripline – Dummy load access**

- ? PEIs DC-OFF.
- ? 480 V<sub>AC</sub> breaker OFF – Locked – verify 480 V<sub>AC</sub> power OFF
- ? Open – observe shorting relay, resistors – lock center bay doors first side.
- ? Open – observe shorting relay, resistors - center bay on second side.
- ? Test resistive ground stick.
- ? Ground capacitor/SCR buses.
- ? Test hard-ground stick
- ? Ground capacitor/SCR buses, attach grounding clip-leads.
- ? Verify clip-lead placement - Close and lock doors.
- ? Re-enter first side.
- ? Test resistive ground stick.
- ? Ground capacitor/SCR busses.
- ? Test hard-ground stick.
- ? Ground capacitor/SCR buses, attach grounding clip-leads.
- ? Verify clip-lead placement - close and lock doors.
- ? Place “Capacitors Grounded” tag on 480 V breaker.

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

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

## **Attachment II**

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

From capacitor bank – PEI maintenance activity

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

**From Horn, Stripline, Dummy Load access**

- ? Remove all grounds
- ? Stow ground sticks
- ? Close – lock all doors
- ? Clear area and advise area personnel
- ? All controls in OFF position
- ? Remove locks/tags from breaker(s)
- ? Notify Control Room personnel as necessary
- ? Energize system per current Operations Procedure.