

REVIEW AND CONCURRENCE RECORD

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1 PURPOSE AND SCOPE

1.1 GENERAL

A power supply system has been built for the purpose of pulsing the NuMI focusing horns. This production power supply will eventually be used to pulse the horns at the NuMI target pile. For the next couple years, the supply will be used at MI-8 for testing of prototype and production horns for NuMI. This unit displaces the NuMI test power supply for the next couple years. Various field, temperature, vibration, and life tests will be carried out on the horns using this equipment. Two 240kW PEI power supplies, configured to provide up to 1200 volts, charges the capacitor bank. The charging source and capacitor bank, working together, are designed to provide 205 kA to the horn, split between 4 separate stripline sections.

The purpose of this procedure is to provide instructions for unattended testing of NuMI horns using the prototype horn power supply. To this end many interlocks have been installed in the system (see Appendix 6.2). It does not include the mounting of the horn on the test stand or the connecting of the stripline to the horn and power supply. It does include testing future horns, which would be similar in style to the present ones, with the NuMI prototype horn power supply.

The NuMI horns are aluminum and of lengths of order 4 meters. The current travels down the outer conductor and back up the inner conductor, producing an azimuthal magnetic field between the conductors. The equipment is installed in the south end of the MI-8 service building. A copy of this procedure, its reference documents, and other pertinent horn test procedures reside in the documentation tray affixed to the MI-8 horn test cage. Emergency procedures and a call list are also affixed to the MI8 horn test cage.

1.2 INTENT AND GOALS

The intent of this procedure is to describe the necessary steps for turning on and off the power supply and water to the horn in a safe manner. Additionally, general data collection information and general safety concerns are described.

2 RESPONSIBILITIES

2.1 BD NuMI Beam Technical Components (L2) Manager

The BD NuMI Neutrino Beam Technical Components (L2) Manager is responsible for:

- a) Overseeing preparation of this procedure;
- b) Distributing this procedure to the necessary personnel.

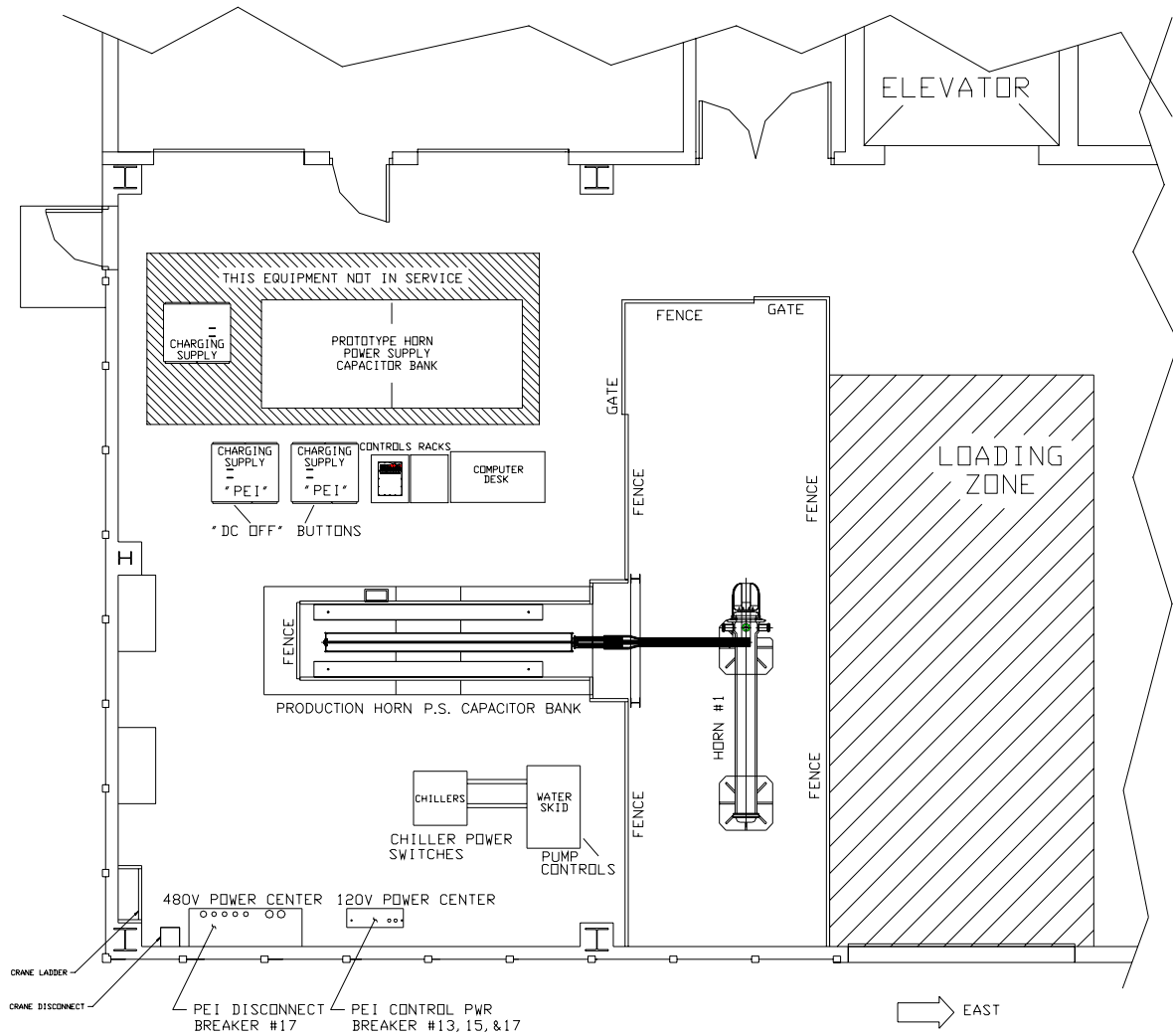
2.2 NuMI DEPARTMENT HEAD

BD Department Heads are responsible for:
Supervising the implementation of this procedure by department personnel.

3 INSTRUCTIONS

A floorplan of the equipment configuration is shown in Figure 1. Note the locations of the charging supplies (240kW PEI), horn power supply capacitor bank, water skid, horn #1 and the fence and gates.

Figure 1: NuMI Horn Testing Floor Plan at MI8 with production power supply



MI-8 FLOOR PLAN FOR NuMI HORN TESTING

3.1 Water System Start-up

All operational aspects of the NuMI horn inner conductor cooling water supply skid operation are documented in the NuMI Test Horn LCW Skid Operators Manual (reference 5.1). Startup, shutdown, interlock details, troubleshooting information, and a list of water skid technician and engineering contacts with corresponding phone/pager numbers is included in this manual.

3.2 Electronics System Start-up

The electronics rack next to the 240 kW PEI contains the trigger/function generator for the power supply, the current balance interlocks, and the pulse counter for the power supply. These are normally powered up and set correctly. If the power is off to any of these, see the instructions in Appendix 6.4.

The horn water skid electronics and interlocks are located on the water skid. They are also normally always on. The interlocks for the water skid need to be reset at start-up.

3.3 Power Supply System Start-up

With the 480V electrical breaker locked out, the PEI power supply, and thus the prototype horn power supply can not be powered up. When the system is ready to be started up, a person trained in the prototype power supply LOTO procedure (Equipment Specific Lockout/Tagout Procedure: BDDP-EE-9916, reference 5.2) will search the cage area, do a pre-start-up inspection of the area, and pull the gate so that it is closed and locked. Personnel need to remove their locks from the 480V breaker. The configuration control lock is the last lock to be removed from the 480V breaker. Only personnel trained in the prototype horn power supply LOTO procedure can remove this lock. The LOTO trained person shall then follow the LOTO procedures for getting ready to start the horn power supply. General procedures for starting up the power supply are given in Appendix 6.4. A Call List is given in Appendix 6.2 in case of problems in start-up or running.

3.4 Data Collection

The prototype horn testing will typically occur overnight and over the weekends. Normal hours of operation will be from 4pm to 8am weekdays and from 4pm Friday to 8am Monday. The repetition rate will typically be 1 to 1.9 seconds and the current level typically 205 kA (4.09 Vpp on the function generator). Each day entries of power supply current, number of pulses, any interlock system trips, and other parameters listed in Appendix 6.3 will be logged. If the system has tripped off overnight or anything unusual is noticed, an expert will be called (see Call List in Appendix 6.1), and the problem will be understood before testing continues. The nature of the trip (over current, etc) will be noted in the log.

3.5 Power Supply System Turn Off and Shutdown

The PEI power supplies recharge the capacitor bank after each pulse. Push the "DC off" button on the power supplies to turn off capacitor recharging, and thus horn pulsing. Note that this does not of itself discharge the capacitor bank. If access to horn or power supply is desired, the LOTO procedures must then be followed to shut down the horn power supply (by trained personnel). It is planned to turn off the power supply on day shifts for noise abatement. If it will be off more than one shift, the power supply will also be shut down, which involves the LOTO procedure and manually grounding the capacitor banks.

3.6 General Safety Considerations

Qualified personnel will know the combination to the configuration control lock on the 480V breaker for the PEI power supplies. A list of qualified

personnel, emergency instructions, and the Call List are posted outside the NuMI Prototype Horn test cage door.

The red strobe light above the capacitor bank flashes when the power supply is operating. In addition, several general safety warning signs are posted on the MI-8 test cage. Such posting includes "Danger High Voltage" signs around the cage perimeter, and a "NuMI Horn Test Stand" sign at each cage entry gate. These detail that high voltage is present during testing, and both LOTO training and reading and signing the NuMI Horn Test Stand Hazard Analysis document (reference 5.3) are prerequisites for test cage access.

Additional horn test documentation exists in the documentation tray affixed to the MI-8 horn test cage. Included are the power supply logbook and a white binder reference detailing the Safety Assessment Report and Readiness Review (reference 5.4).

In an effort to insure safety of personnel, two people will be present any time the LOTO procedure is carried out and when the daily horn testing is started (two-man rule). Stopping pulsing by pushing the PEI DC off buttons may be done by one person. Only qualified personnel will enter the cage and only after they have put their LOTO lock on the 480V circuit breaker. They will leave the cage door open while they are inside but lock it behind them as they leave.

An important safety consideration is the stripline. Personnel should refrain from investigations of the stripline during testing. Work which might cause them or something that they are moving to touch the stripline must be avoided during pulsing.

MiniBoone personnel, the Operations Department Head, the Fermilab Fire Chief and the MI8 building manager have all been notified of this operation and sent copies of the emergency procedures.

3.7 LOTO Safety Considerations

LOTO Procedure BDDP-EE-9916 applies to this equipment. It is required that personnel will follow the LOTO procedure when turning on or off the power supply, or entering the cage.

4 DISTRIBUTION

A controlled copy of this procedure shall be assigned and distributed to the Beams Division Operations Department Head.

Additional controlled copies shall be distributed as deemed appropriate by the NuMI Department Head.

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

5 REFERENCES

5.1 NuMI Test Horn LCW Skid Operators

5.2 Equipment Specific Lockout/Tagout Procedure: BDDP-EE-9916

5.3 NuMI Horn Test Stand Hazard Analysis Document

5.4 Safety Assessment Report and Readiness Review

6 APPENDICES

6.1 Emergency Instructions and Call List

In the event of an emergency (non-life threatening).

- Push DC off on the PEI power supplies as shown in the figure below.
- If a water problem, turn off the water at the chiller and pump controls as shown in the figure below.

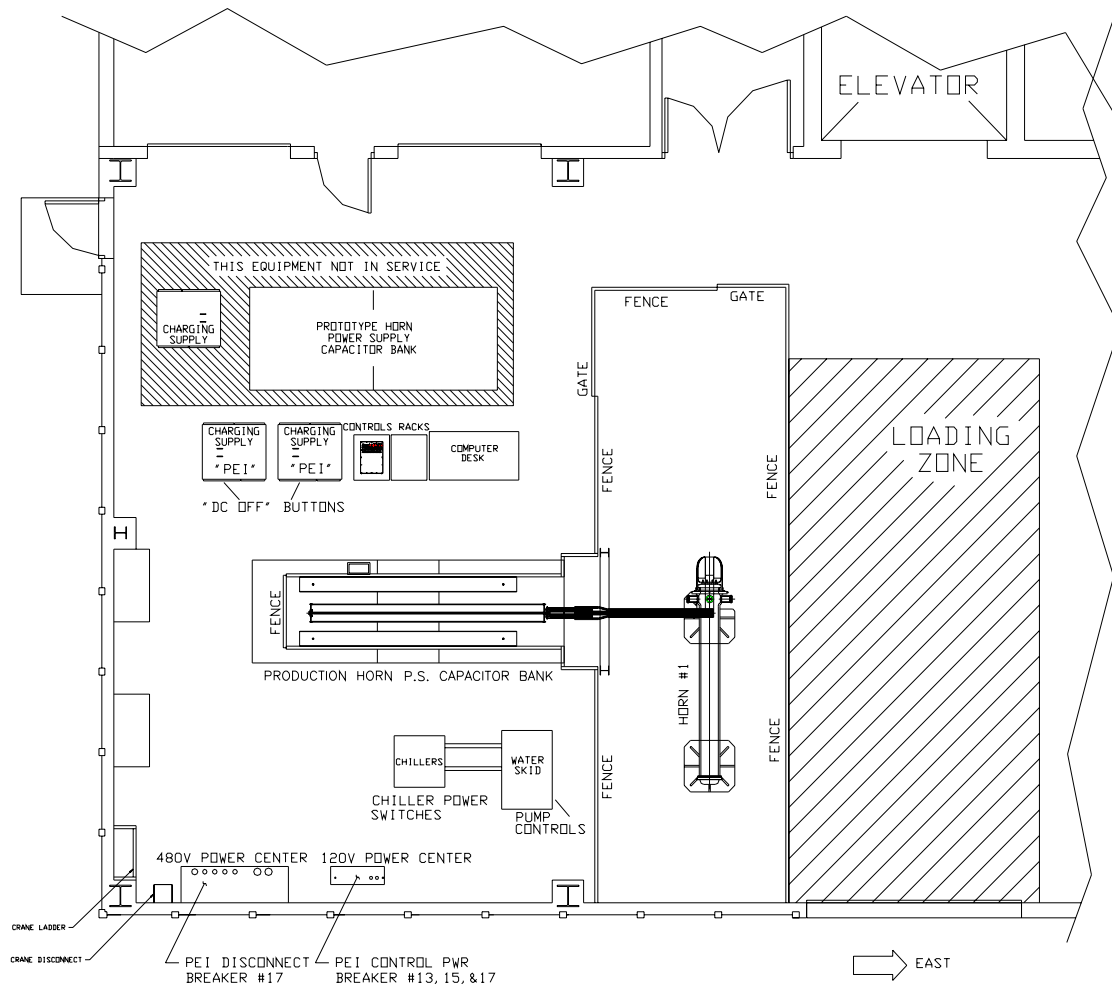
Notify one of the following people:

#1: Hiep Le (x2549, LRP 630-722-8463, cell: 630-319-3645, home: 630-942-8408)

#2: Joe Lazzara (x8864, x8865, LRP: 630-722-5806, home: 630-584-5694)

#3: Jim Hylan (x2122, LRP 630-905-7685, home: 630-396-2614)

The prototype horn testing will typically occur over night and over the weekends. Normal hours of operation will be from 4pm to 8am weekdays and 4pm Friday to 8am Monday.



MI-8 FLOOR PLAN FOR NuMI HORN TESTING

6.2 General Call List for Repairs/Problems:

Area	Name	Office	Pager	Home
<u>Horn</u>	Kris Anderson	X4947	847-536-5468	815-836-8802
	<u>Jim Hylan</u>	X2122	630-905-7685	630-396-2614
<u>Water</u>	<u>Hiep Le</u>	X2549, X8864	630-722-8463	630-942-8408
	<u>Joe Lazzara</u>	X8864, x8865	630-722-5806	630-584-5694
	John Seidelman		630-722-6633	
<u>Power Supply**</u>	<u>Ken Bourkland</u>	X3813	630-266-8706	630-584-4972
	<u>Nancy Grossman</u>	X3810	630-905-7685	630-513-5449
	<u>Alberto Marchionni</u>	X5152		
	Howie Pfeffer	X4425	630-314-1385	
	Dan Wolff	X4052		
	<u>Frank Nezrick</u>	X4604		
	<u>Hiep Le</u>	X2549, X8864	630-722-8463	site pager X0468
<u>PEI (240)</u>	Steve Hays	X2337	847-536-1984	630-231-6584

** The names of people who are qualified in LOTO for the horn power supply (BDDP-EE-9916) are underlined. Changes in this list will be posted at MI-8, but do not require re-approval of the procedure.

6.3 MI8 Horn Test Setup Interlocks for Unattended Operation

The following inputs are in the PEI interlock system and will cause the PEI to shutdown if they are out of tolerance. The PEI PS and water skid control panels control box have indicators to show which interlock may have shut down the power supply.

PEI PS:

- DC overcurrent on PEI.
- Overtemp on PEI (Built into the PEI-standard equipment)
- PEI doors (open)
- Cage entrances (open)

Cap Bank:

- Capacitor bank doors (open)
- Current Interlock.
An auxiliary electronics chassis monitors the four currents from the Pearson current transformers of the capacitor bank. It was built as an addition to the test power supply to monitor the four transmission line currents on a pulse by pulse basis, sensitive to any combination of current imbalance of approximately 10% between the four capacitor bank sections or striplines. It will shut down the PEI P.S. for both over and under current conditions from one or more sections of the capacitor bank or striplines. It averages the waveform of the 4 sections and compares the individual section waveforms to this average. There is also an overall over-current interlock, set at 220 kA. The overall over current trip point, the section current high trip point and the section current low trip point are all separately adjustable.

Water systems:

- Differential pressure interlock on the PEI and cap bank cooling water
- #3 flow switch on the water supply manifold for the inner conductor cooling nozzles. A flow rate less than 16 gpm to the horn cooling nozzles will drop the charging supply permit. The trip limit is set by removing the cover on the relay and turning a set screw while looking at the large flow meter in the main supply line.
- #1 resistivity probe (probe A) on the water supply manifold for the inner conductor cooling nozzles. A resistivity numerically less than $4\text{M}\Omega\text{-cm}$ will drop the charging supply permit. A resistivity numerically less than $5\text{M}\Omega\text{-cm}$ will open the solenoid valve on the DI bypass loop to allow water flow in the polishing loop which reduces the cooling water conductivity. The solenoid valve closes when the water conductivity reaches $6\text{M}\Omega\text{-cm}$. These limits are set by programming the Thornton meter interfaced with probe A.
- #1 temperature probe (probe A) on the water supply manifold for the inner conductor cooling nozzles. A nozzle water supply temperature above 75°F drops the charging supply permit. The temperature limit is set by programming the Thornton meter attached to probe A. This relay does not trip the 3 hp supply pump.

- Horn water supply temperature relay which is set to trip the 3 hp pump if the supply temperature reaches 95°F. This relay is in place to protect the horn from encountering excessively warm water in the event that the chillers fail. Water temperatures above 75°F will drop the charging supply permit, and water to the horn in excess of 95°F will turn off the water supply to the horn (and drop the charging supply permit on low horn water flowrate) . The relay is set to allow the system to be manually restarted for 3 minutes (adjustable from 1 to 10 minutes) to allow water to circulate and bring the system temperature down once the chillers have been manually re-started.
- A differential pressure switch across the 3 hp water skid pump is adjusted to protect the pump from surges or lack of suction side water supply. If the switch trips on unacceptable pressure limits, the charging supply permit will subsequently trip on low flow rate.

Configuration Control Lock Scheme:

- There is a combination configuration control lock for securing the PS System. Only LOTO trained/qualified (in BDDP-EE-9916) people are given knowledge of the combination. Removing the combination lock enables operation of the PS.
- The existing LOTO procedures are then followed for operation, shutdown, and entry. When the system is shut down after operations conclude, the configuration lock is to be placed on the breaker and all LOTO locks removed, allowing any of the other qualified persons to initiate subsequent operation.

6.4 Data Log List

Items that will be logged either electronically or by hand are:

- Alarmed interlock system parameters (power supply and water)
- Power supply current for each of the four sections
- Number of pulses
- Temperature probes
- Water cooling system (horns) flow rate
- Water cooling system (horns) conductivity
- Water cooling system (horns) temperature
- Horn field

6.5 Guidelines for Start-up/Shutdown of the Horn Power Supply

SHUTTING DOWN THE PROTOTYPE POWER SUPPLY:

Hit DC off on the PEI and follow LOTO procedures in "Manual Equipment Specific Lockout/Tagout Procedure: BDDP-EE-9914"

TURNING PROTOTYPE POWER SUPPLY ON

Follow the LOTO procedures in "Manual Equipment Specific Lockout/Tagout Procedure: BDDP-EE-9916" to prepare the system for startup. Then:

1. This function generator is normally set correctly, but will need to be reset if lose AC power. Check 5 Function generator items:
 - Shift Arb (function), > to scroll. Generally want NuMI_1_9 (rep rate is 1.9 sec). Hit enter when get to NuMI_1_9. (others are NuMI_1_0 and NuMI_0_5, which are 1.0 and 0.5 sec. Respectively).
 - Freq, >,< to get to decimal place you want it to be at and get from 1 KHz to 526 mHz (1 pulse every 1.9 sec)
 - Amp, set to 25 mV pp
 - Offset, set to -30 mV (-0.03 Vdc)
2. Turn handle on for PEIs
3. Hit fault resets
4. Push "DC on" on both supplies.
5. Turn up to desired voltage on the function generator (see table below).
6. There is a "sum" output @ 40 KA/V that can be checked.
7. For emergency hit DC off on PEIs.

CURRENT/VOLTAGE CONVERSIONS

Current (kA)	Voltage on Function Generator	Measured current on scope (all channels) kA	Current/channel (approximately) (kA)
100	2.03Vpp	103	25
150	3.05Vpp	153	37.5
200	4.09 Vpp	203	50

FREQUENCY CONVERSIONS:

Period (sec)	Frequency (mHz)
1	1000
1.9	526
5	200
8	125

Changes in these guidelines, such as use of a different control to set current, will be posted at MI-8, but do not require re-approval of the procedure.