BEAMS DIVISION NuMI DEPARTMENTAL PROCEDURE

NUMI DEPARTMENT

BDDP-NU-0001

NuMI HORN TESTING AT MI8 PROCEDURE

RESPONSIBLE DEPARTMENT NuMI

PREPARED BY _____ DATE _____
Jim Hylen
BD NuMI Technical Components (L2) Manager

APPROVED BY _____ DATE _____
Greg Bock
NuMI Department Head

REVISION NO. 0 REVISION ISSUE DATE _____

REVIEW AND CONCURRENCE RECORD

REVIEWED BY: _____ DATE: _____
Dan Wolff
EE Support Department Head

REVIEWED BY: _____ DATE: _____
Fritz Lange
Mechanical Support Department Head

REVIEWED BY: _____ DATE: _____
Bob Mau
Operations Department Head

REVIEWED BY: _____ DATE: _____
John Anderson
SSO, Beams Division

TABLE OF CONTENTS

1 PURPOSE AND SCOPE

1.1 GENERAL

A power supply system has been built for the purpose of pulsing the prototype NuMI focusing horns. Various field, temperature, vibration, and life tests will be carried out on the horns using this equipment. When construction of the operational power supply is completed, it will replace this unit. A 240kW PEI power supply, configured to provide up to 800 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, the same general data collection information and general safety concerns are described.

2 RESPONSIBILITIES

2.1 BD NuMI Technical Components (L2) Manager

The BD NuMI Technical Components (L2) Manager is responsible for:
a) Preparing this procedure;
b) Distributing this procedure to the necessary personnel.

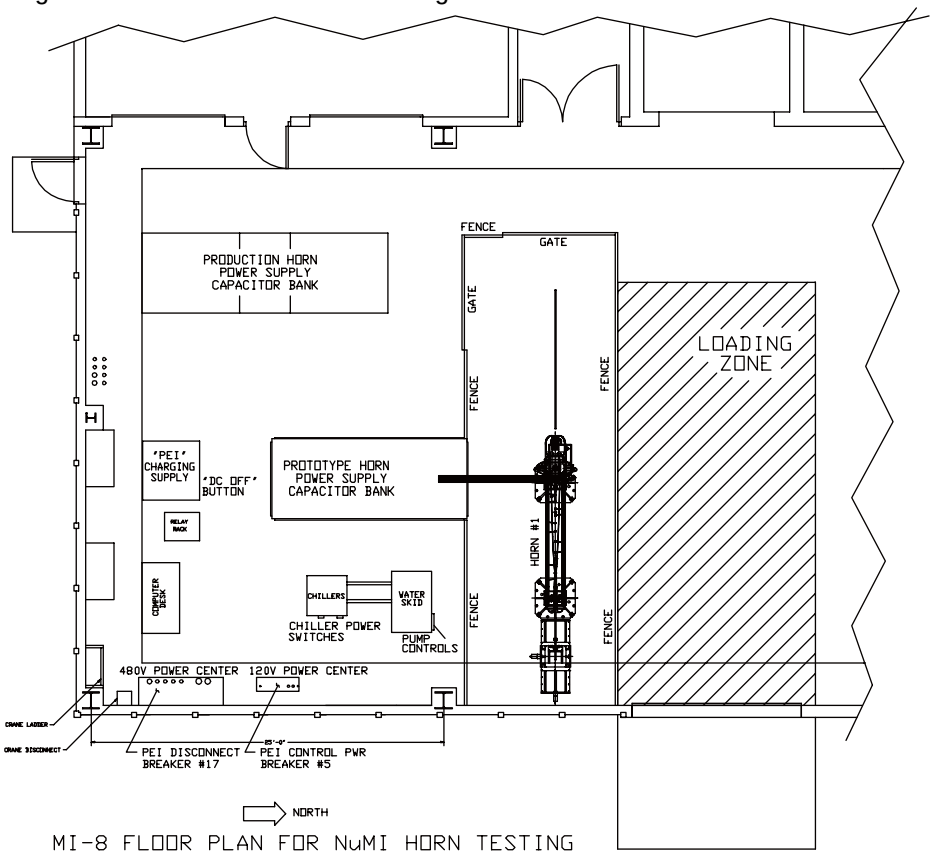
2.2 NuMI DEPARTMENT HEAD

The NuMI Department Head is 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 supply (240kW power supply). Prototype horn power supply capacitor bank, water skid, horn #1 and the fence and gates.

Figure 1: NuMI Horn Testing Floor Plan at MI8



3.1Water 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.

3.2Electronics System Start-up

The electronics rack next to the 240 kW PEI power supply 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.

3.3Power 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 (Manual Equipment Specific Lockout/Tagout Procedure: BDDP-EE-9914, 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 prototype horn power supply. General procedures for starting up the power supply are given in Appendix 6.4. A Call List is posted on the MI8 horn test cage. It lists people trained in BDDP-EE-9914, and people to call in case of problems in start-up or running the system.

3.4Data Collection

The prototype horn testing will typically occur overnight and over the weekends. Normal hours of unattended operation of the prototype horn testing 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 the alarmed interlock system parameters (power supply and water), power supply current, number of pulses 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 (posted on the prototype horn test fence out at MI8), and the problem will be understood before testing continues. The nature of the trip (over current, etc) will be noted in the log.

3.5Power Supply System Shutdown

The PEI power supply powers the capacitor bank, thus pushing the “DC off” button on the power supply turns it off. It is recommended that the trigger to the capacitor bank be switched off by turning off the control power circuit breaker (blue switch) on the left side of the PEI power supply control panel to increase equipment longevity. The LOTO procedures must then be followed for the prototype horn power supply (by trained personnel).

3.6General Safety Considerations

Qualified personnel will know the combination to the configuration control lock on the 480V breaker for the PEI power supply. A list of qualified personnel, emergency instructions, and the Call List are posted outside the MI8 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 during daily supply turn-on, turn-off (two-man rule). 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.

3.7LOTO Safety Considerations

LOTO Procedure BDDP-EE-9914 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

5.1NuMI Test Horn LCW Skid Operators

5.2Manual Equipment Specific Lockout/Tagout Procedure: BDDP-EE-9914

5.3NuMI Horn Test Stand Hazard Analysis Document

5.4Safety Assessment Report and Readiness Review

6 APPENDICES

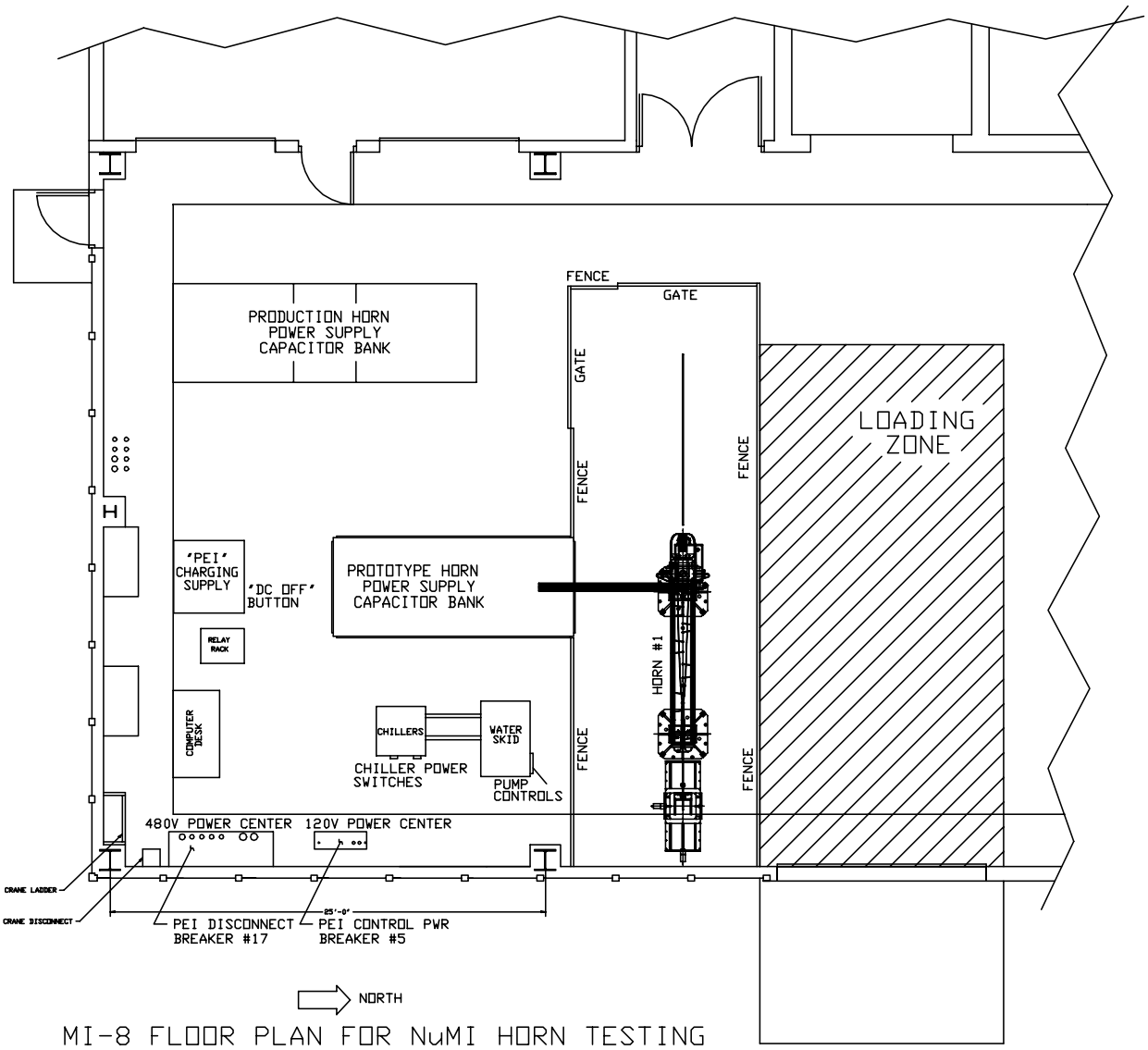
6.1 Emergency Instructions

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

- Push DC off on the PEI power supply 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 Hylen (x2122, LRP 630-905-7685, home: 630-396-2614)

The unattended prototype horn testing will typically occur over night (4pm to 8am) and over the weekends (4pm Friday to 8am Monday).



MI-8 FLOOR PLAN FOR NuMI HORN TESTING

The capacitor bank had been upgraded for unattended operation in several ways. A second 1-ohm, 1.2 kW resistor had been added in parallel with the existing one in the capacitor bank yielding a combined value - 0.5 Ohm. This will reduce the power dissipation for this component, compensating for the higher power dissipation expected during operation at the faster rep-rates. An air to water heat exchanger had also been added, with a blower, inside of the capacitor bank enclosure to aid with cooling and preventing heat build-up within the enclosure.

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

PEI Power Supply:

- DC overcurrent on PEI power supply.
- Overtemp on PEI power supply (Built into the PEI power supply-standard equipment)
- PEI power supply 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 power supply 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 power supply 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 resisitivity numerically less than 4MΩ-cm will drop the charging supply permit. A resistivity numerically less than 5MΩ-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 6MΩ-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^{o}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^{o}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^{o}F will drop the charging supply permit, and water to the horn in excess of 95^{o}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.

<u>Configuration Control Lock Scheme:</u>

- There is a combination configuration control lock for securing the PS System. Only LOTO trained/qualified (in BDDP-EE-9914) 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.

6.3 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

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

SHUTTING DOWN THE PROTOTYPE POWER SUPPLY:
Hit DC off on the PEI power supply 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-9914" 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 PEI power supply
3. Hit fault reset
4. Push "DC on".
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 PEI power supply.

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