MAIN INJECTOR AND RECYCLER OJT

This OJT provides you with a checklist, guideline, and record of your Operator II Main Injector and Recycler (MI and RR) training, and also introduces you to regular operational procedures as well as physical locations of equipment. **It is very important that you do not lose this document.** If you lose this document the training you have completed will have to be redone.

This training list has been successfully completed.

Department Head (Signature/Date)_____

Contents

MAIN INJECTOR & RECYCLER TRAINING

Part 1: MCR

1.1 Introduction

Trainer Date

1. MI and RR Lattice

____ Know the type of lattice for both MI and RR

____ Understand the following aspects of the MI and RR lattice:

- ____ Know where the high dispersion regions are located
- ____ Know where the low dispersion regions are located

Trainer Date

2. Tunnel Layout

____ Understand the numbering convention

- ____ Know which locations have focusing or defocusing quadrupoles
- ____ Know which locations have horizontal or vertical trims

____ Be familiar with the naming and numbering conventions for the following beamlines:

- ____ 8 GeV Line (MI-8)
- ____ RR 8 GeV Line (RR-8)
- ____ RR to MI Line
- ____ P1 and P2 Lines
- ____ RR to P1 Line
- ____ Abort Line

____ Know where the injection and extraction elements are and in which plane they bend the beam:

- ____ MI-8 injection
- ____ RR-8 injection
- ____ RR to MI transfer
- ____ RR to P1 Line extraction
- ____ MI P1 Line extraction
- ____ NuMI extraction
- ____ Abort Line and gap clearing extractions

____ Know where the MI tunnel access points are

____ Know where the RF cavities are located

____ MIRF

____ RR 52.8 MHz RF

____ RR 2.5 MHz RF

Trainer Date

3. Permanent Magnets

____ Regular gradient

____ Be able to draw a pole shape diagram for an RGF and RGD magnet

____ Dispersion suppressor gradient magnets

____ Quad

____ Mirror

Trainer Date

4. RR Magnetic Shielding

____ Magnetic shielding is composed of the following:

____ Soft iron

____ Mu metal

____ Fiberglass sheets

____ Know why this magnetic shielding is necessary

Trainer Date

5. RR Ramp Correction

____ Know the purpose of the RR Quad Compensation Loop (QCL)

____ Know where in the tunnel QCL is located

____ Know why the RR dipole trims are ramped

____ Be able to identify the corresponding ramp table

____ Know which types of RR tune shift compensation are used

____ Be able to view these compensation tables

Trainer Date

6. Injection

____ Be able to construct a basic outline of the beam path through the 8 GeV Line, RR-8 Line, RR and into MI

____ Know how beam is switched into the RR-8 Line

____ Know the location of RBEX in the 8 GeV Line

Trainer Date

7. Single-Turn Extraction

____ Be able to construct a basic outline of the beam path from RR and MI to the beamlines

____ Be familiar with how kickers are triggered

- ____ TCLK event
- ____ 377 delay
- ____ BSCLK event
- ____ 379 delay

____ Know the purpose of the MI extraction time bumps

- ____ Be able to determine which cycles have them

Trainer Date

8. Resonant Extraction

____ Know the role of the following in resonant extraction:

- ____ MI tune
- ____ Harmonic quad trims
- ____ QXR
- ____ Bucker
- ____ Electrostatic septa

____ Be familiar with the procedure for rebooting the QXR front end

- ____ Understand that experts should be contacted

____ Know how to plot QXR current and beam and be familiar with what it should look like when it is working properly

____ Know how and when to reset the memory of QXR

- ____ Recall that an MIBEAM or MECAR reboot requires a QXR memory reset

____ Know how to plot the bucker current and the RF spill monitor readback

Trainer Date

9. Gap Clearing Kickers

____ Know the purpose of the RR gap clearing kickers

____ Know when gap clearing kickers are fired

____ Know which gaps the kickers clear

____ Know where the gap clearing kickers send the beam they clear

Trainer Date

10. Slip-stacking

____ Understand the purpose of slip-stacking beam in RR

____ Be familiar with how the process of slip-stacking occurs in both RR and MI

Trainer Date

11. Re-bunching

____ Understand the purpose of re-bunching beam in RR for the g-2 experiment

____ Be familiar with how the process of re-bunching occurs in RR

1.2 Safety

Trainer Date

1. Electrical Safety System (ESS)

____ Identify the inputs to the MI ESS

____ Know which devices are interlocked to the MI ESS

Trainer Date

2. Critical Devices

____ Know which CDC protects the MI-10 and 8 GeV Line enclosures

____ Be familiar with the modes of operation of this CDC

____ Identify the critical devices interlocked to this CDC

____ Know which CDC protects the MI20-62 enclosure

____ Identify the critical devices interlocked to this CDC

____ Identify the CDCs that protect F-Sector

____ Identify the critical devices interlocked to this CDC

____ Understand the implications of accesses into F-Sector, Transport Mid, MI-12A, or MI-31 Stub

Trainer Date

3. MI and RR Access Hazards

____ Hazards that may exist in supervised and controlled accesses

____ Understand the radiation hazards associated with the RF cavities

____ Understand the hazards associated with the collimation sections in the 8GeV Line, Main Injector, and Recycler

Trainer Date

4. Miscellaneous Safety

____ Know that the MI tunnel is split into two enclosures

____ Know that MI and RR share an RWP

____ Know what happens when an emergency exit mini-loop is accessed

____ Know the locations and layouts of the MI/TeV Crossovers

1.3 Power Supplies

Trainer Date

1. MI Turn Off and On

____ Know which devices are turned off or on via the sequencer

____ Know the appropriate CDCs to manipulate

____ Know how to use the MI power supply status and control application to perform the following:

____ Manipulate the permit and hipot loops

____ Open and close VCBs

____ Perform and interpret the hipot analysis results

____ Know how to turn the machines off or on before and after an access using the following procedures:

____ Main Injector, F-Sector & Transfer Hall Exposed Bus Lockout/Tagout Procedure ADSP-05-1210

____ Kautz Road Substation MOS 86, 87 & 89 Lockout ADSP-05-1214

____ Know how to become qualified for these procedures

____ Know how and when to reset 8 GeV Line magnetic fields

Trainer Date

2. Power Distribution

____ Know which MOS(s) supply pulsed power for the main MI power supplies

____ Know which MOS(s) supply pulsed power for the MI related beamlines

____ Know which MI and RR power supplies are locked out with the house safety disconnects at MI-10 and MI-30

Trainer Date

3. MI Bus Power Supplies

____ Know the locations of the MI quad bus power supplies

____ Focusing

____ Defocusing

____ Know how the bus covers are accessed

____ Know what needs to be done before powering supplies

____ Understand who is allowed to manipulate Main Injector Power Supply knife switches

____ Understand that all power supplies are needed in the circuit to maintain normal operational ramp rates

Trainer Date

4. MI Excitation Controller And Regulator (MECAR)

____ Be familiar with what MECAR regulates, how it does so, and how to plot bus current error signals

____ Know when and how to do the following using the MECAR control application:

____ Enable or halt the MI ramp

____ Put the MI ramp in DC mode

____ Modify the power supply turn-on order

Trainer Date

5. RR Quad Phase Trombone

____ Understand how the RR phase trombone is used to control the tune

____ Know the locations of the RR phase trombones

Trainer Date

6. MI Sextupole Power Supplies

____ Know the location of the sextupole power supplies

____ Understand the impact of an F-Sector access on the sextupole power supplies

Trainer	Date

7. Correction Element Power Supplies

____ Know the various types of correction elements in both MI and RR

- ____ Horizontal and vertical dipoles
- ____ Quads
- ____ Skew quads
- ____ Sextupoles

____ Be familiar with the purpose of the bulk supply and the individual regulators

- ____ Be aware of the RMS and DC current limits for the correctors

____ Know the ramp card used for controlling MI and RR correction elements

____ Be able to do the following:

- ____ Display digital status for the bulk supply and regulator
- ____ Reset and turn on or off a correction element bulk supply
- ____ Reset correction element regulators
- ____ Know that I:QTxxx wide aperture quad trims cannot be reset during the MI ramp due to field coupling between the trim and main MI quads
- ____ Enable and disable ramps for correction elements
- ____ Modify, save, and restore correction element ramps

____ Know the proper procedure for changing out a correction element regulator

1.4 RF Systems

Trainer Date

1. High Level RF Control and Operation

____ Be able to plot station parameters, such as gap envelope or modulator voltage

____ Know how to respond to various watchdog trips

- ____ Be familiar with what the MIRF watchdog system monitors

____ Know how to respond to various modulator, MEIU, bias supply, and anode supply trips

____ Know how to bypass an RF station

- ____ Understand that RR RF stations cannot be swapped without expert intervention
- ____ Know how to turn off a MI RF station locally and remotely
- ____ Know how to bypass a station from the NuMI abort MIRF summation chassis
- ____ Know how to update the number of stations from MI RF Controls, I3

____ Display diagnostic trip logs

Trainer Date

2. High Level RF Components

____ Understand the function of the HLRF components

- ____ Anode supply
- ____ Modulator
- ____ Solid state driver
- ____ Power amplifier
- ____ RF cavity
- ____ Ferrite tuners
- ____ Bias supply

____ Understand the basic differences between Booster, MI, and RR cavities

Trainer Date

3. LLRF

____ Know how to reboot the MI and RR LLRF systems

____ Know what other systems are impacted by rebooting the LLRF

____ Be familiar with the operating RF frequency range for MI and RR

Trainer Date

4. Dampers

____ Recycler Bunch-by-bunch dampers

____ Understand the role of the Recycler Bunch-by-bunch dampers

____ Recycler Diode damper

____ Understand the role of the Recycler diode damper in slip stacking

____ Main Injector D2 dampers

____ Understand the role of the Main Injector D2 dampers

____ Know how and when to reboot the dampers

1.5 Beam Abort Systems

Trainer Date

1. Abort Links

____ Be familiar with the purpose and layout of the MI and RR abort links

____ Know how to diagnose MI and RR beam aborts and how to reset the abort links

____ Be able to jumper and un-jumper inputs to the abort links

____ Understand who must authorize this

Trainer Date

2. Abort Kickers

____ Be able to verify and set the abort clean-up times for any cycle

____ Understand the two different ways the abort kickers are triggered

1.6 Beamlines

Trainer Date

1. MI-8 Line

____ Be familiar with the purpose and layout of the MI-8 Line

- ____ Powered elements on the upstream end of the line
- ____ Know where the permanent magnets start in the MI-8 Line, and how far down the line they go
- ____ Powered elements on the downstream end of the line

Trainer Date

2. RR-8 Line

____ Be familiar with the purpose and layout of the RR-8 Line

- ____ Know that the beamline is composed of both powered trims and permanent magnets
- ____ Know which magnet injects beam into the RR-8 Line

Trainer Date

3. RR to MI Line

____ Be familiar with the purpose and layout of the RR to MI Line

- ____ Vertical bend magnets
- ____ Quads
- ____ Correctors

Trainer Date

4. RR to P1 Line

____ Be familiar with the purpose and layout of the RR to P1 Line

- ____ Main bend magnets
- ____ Quads
- ____ Correctors

Trainer Date

5. P1 and P2 Lines

____ Be familiar with the purpose and layout of the P1 and P2 Lines

- ____ Main bend magnets
- ____ Quads
- ____ Correctors

1.7 LCW Systems

Trainer	Date

1. MI Magnet Cooling

____ Understand the flow path for the magnet cooling system

____ Know the source of the MI make-up water

____ Be familiar with how this LCW system maintains head pressure and what to do if the pressure falls too low

____ Know with which water this LCW system heat-exchanges

- ____ Understand that the MI-20 LCW system uses a cooling tower to maintain LCW temperature

____ Understand the MI Magnet LCW system can run in two modes

- ____ CUB
- ____ Internal Recirculation
- ____ Know how to tell what mode the MI Magnet LCW system is in

____ Know how many LCW pumps can be off and still allow for normal operation

- ____ Understand the implications of turning off the MI-60 Magnet System LCW pumps
- ____ Understand what happens to the Main Injector when the LCW system differential pressure is too low

____ Understand how the LCW pumps are interlocked to the pond pumps for that house

____ Be able to monitor the LCW system

- ____ Supply pressure
- ____ Return pressure
- ____ Temperature
- ____ Leak alarms
- ____ Status and control of two-speed pumps

Trainer Date

2. MI-60 Cavity Cooling

____ Know the location of the MI-60 cavity LCW cooling system

____ Know the source of the cavity system's make-up water

____ Know with which water this LCW system heat-exchanges

____ Be familiar with the general operating temperature and pressure ranges for the cavity LCW system

____ Know which department is responsible for this water system

Trainer Date

3. MI-60 RF Gallery Cooling

____ Know the location of the RF gallery LCW cooling system

____ Know how the RF gallery system makes up water

____ Know with which water this LCW system heat-exchanges

____ Be familiar with the general operating parameters for the RF gallery LCW system

____ Know which department is responsible for this water system

Trainer Date

4. RR Cooling

____ Be familiar with the devices in RR that use MI's LCW for cooling

Trainer Date

5. MI-31 RF Cooling

____ Know the location of the MI-31 RF LCW chiller

____ Know what this system makes up from

____ Know how the system maintains the LCW temperature

Trainer Date

6. P1 & P2 Line Cooling

____ Identify which LCW systems cool the following P1 and P2 Line equipment:

____ P1 Line magnets

____ P2 Line magnets

____ Power supplies at MI-52

____ Power supplies at F0

____ Power supplies at F1

1.8 Vacuum

_____	
Trainer	Date

1. Vacuum

____ Be able to use the MI and RR vacuum applications to check vacuum levels, turn on and off ion pumps, and manipulate vacuum valves

____ Be familiar with nominal vacuum levels in MI and RR

____ Be familiar with the locations of the air compressors for MI and RR's pneumatic vacuum valves

____ Be aware that RR contains both manual and pneumatic vacuum valves

_____	
Trainer	Date

2. Vacuum Controls

____ Know the typical cards that are used in a CIA crate

____ Be familiar with the role of the PiVac Front Ends in the vacuum system

____ Be aware of network connected ion pumps in RR

____ Be aware that some of these pumps are powered from a bulk supply

1.9 MI Controls Systems

Trainer Date

1. CAMAC

____ Understand the layout of the CAMAC link

____ Be able to troubleshoot basic CAMAC system failures

____ Understand which systems use CAMAC controls

____ Know the locations of the MI CAMAC front ends

Trainer Date

2. VME

____ Know which systems use VMEs or VXIs

____ Know where the various crates are located

____ Identify the systems that interface to ACNET through the house VMEs

____ Know which MI service buildings contain HRMs and understand their function

____ Be able to diagnose simple VME or VXI failures

Trainer Date

3. PLC

____ Know which systems use PLCs

____ Be able to diagnose basic PLC failures

1.10 Instrumentation

Trainer	Date

1. BPMs

____ Understand how to acquire injection flash orbits

____ Understand how to acquire last turn flash orbits

____ Know how to acquire a display orbit at any point in a machine cycle

____ Know how to acquire profile frames at each breakpoint

- ____ Know how to set profile frame timers to energy breakpoints

____ Know how to acquire turn-by-turn BPM data

- ____ At injection
- ____ At any point in the cycle

____ Be able to reboot the BPMs

____ Know how to change the BPM states

- ____ Be able to restore nominal values

Trainer	Date

2. BLMs

____ Be able to plot individual BLMs

____ Know how to acquire ring-wide loss displays

____ Be able to identify the abort thresholds for an individual BLM

____ Be familiar with the loss parameters for each machine and what they measure

- ____ Integrated
- ____ Slow
- ____ Fast
- ____ One minute average
- ____ Know how they are generated from one set of loss monitors

Trainer Date

3. Multiwires

____ Be familiar with the locations of the MI and RR multiwires

____ Be able to move multiwires into or out of the beam

____ Be able to plot the multiwires

____ Be aware of the effect multiwires have on circulating beam

Trainer Date

4. Toroids

____ Know where all the MI and RR toroids are located and how to monitor them

Trainer Date

5. DCCTs

____ Know the location of the MI and RR DCCTs

____ Be familiar with the parameters that MIBEAM generates for both machines

- ____ Beam intensities
- ____ Beam energy losses

Trainer Date

6. Tomography

____ Know which beam pick-up the tomography uses to be able to reconstruct the longitudinal phase space distribution of beam

____ Be able to use the MI and RR tomography program, TARDIS, to reconstruct injected beam

- ____ Know how configure and run TARDIS by recalling saved setups for operational states
- ____ Be able to use the reconstructions to tune common longitudinal issues including energy and phase errors
- ____ Be aware of the ‘Start Datalog’ function and the associated parameters

____ Understand that each machine’s tomography oscilloscope is single user

1.11 Tuning

Trainer Date

1. Injection Tuning

____ Know that setting the MI bend field affects the following:

- ____ Smooth orbit
- ____ Desired injection energy
- ____ Closure

____ Know that closure should always be performed after the following changes:

- ____ Adjusting MI bend field offset
- ____ Smoothing
- ____ Adjusting injection energy

Trainer Date

2. MI Bend Field

____ Be able to set the MI bend field offset

- ____ Know why the inject frame orbit is used

Trainer Date

3. Orbit Smoothing

____ Know what needs to be done before smoothing the orbit

____ Be able to smooth the orbit at injection in RR

____ Be able to smooth the orbit at injection and up the ramp in MI

____ Know how to recover and back out of a smooth

Trainer Date

4. Injection Energy

____ Be able to set the energy of beam injected into RR or MI from Booster

- ____ Understand why the MI injection energy is fixed when injecting from RR

Trainer Date

5. Closure

____ Be able to close into RR and MI

- ____ Be able to revert a closure change

Trainer Date

6. Tunes and Chromaticities

____ Be able to measure the tunes at injection and up the ramp

____ Be able to correctly adjust MI tunes and chromaticities

____ Be able to correctly adjust RR tunes and chromaticities

Trainer Date

7. 3-Bump Tuning

____ Know how to correctly set up a 3-bump at various breakpoints

____ Be able to tune out losses with a 3-bump

Trainer Date

8. RPOS

____ Know the location of the RPOS detector in MI

____ Know how to center the beam after feedback-on time

Trainer Date

9. LLRF

____ Know how to tune the injection phase offset

____ Know the following MI specific LLRF adjustments:

____ Know how to tune the acceleration phase offset

____ Know how to tune the transition timing and phase jump

Trainer Date

10. RF

____ Understand how to tune the MIRF high voltage curves

____ Understand how to tune the RRRF high voltage curves

____ Be able to adjust RR 2.5 MHz high voltage (R6)

Trainer Date

11. Beamline Tuning

____ Be able to properly tune kickers, Lambertsons and trims in each beamline

____ Be able to tell which time bumps are used for NuMI extraction and Switchyard extraction

____ Understand the importance of the circulating beam position through the Lambertsons and how to tune it

____ Adjust the P1 and P2 Line power supply ramps with I68

Trainer Date

12. MI and RR Collimators

____ Understand the purpose of collimation systems in MI and RR.

____ Be familiar with the major components of the collimation systems, including their function

____ Know the location and layout of the collimation systems

____ Know how the beam is moved toward the collimators

- ____ Know that MI beam positions should not be tuned at the breakpoints during collimation
- ____ Know that RR beam positions should not be tuned at the collimation locations

Trainer Date

13. MI-8 Autotune Program

____ Understand the purpose and importance of the MI-8 Autotune program

____ Know where it runs and how we interact with it

____ Be able to determine which devices it controls

____ Know how to tell, and what to do, if it is not working correctly

Part 2: Walkaround

Trainer Date

1. MI-8 Service Building

____ Locate the power supply and controls for RBEX

____ 8GeV Line correction element power supplies

____ Understand that some regulators have different output than others

Trainer Date

2. MI-14 Service Building

____ RR injection kicker power supplies

____ Fluorinert skid

____ RR-8 Line correction element power supplies

____ Controls associated with the correction elements

Trainer Date

3. MI-30 Service Building

____ RR to MI Line power supplies

____ Controls associated with the RR to MI Line

____ QXR power supply

____ Bucker power supply

____ Quad bus power supply

____ MI power supply PLCs

Trainer Date

4. MI-31 Service Building

____ RR 2.5 MHz RF amplifiers

____ Cooling skids

Trainer Date

5. MI-39 Service Building

____ RR gap clearing kicker power supplies

____ Fluorinert skid

Trainer Date

6. MI-40 Service Building

____ Abort line power supplies
____ Bend bus power supplies
____ Quad bus power supply
____ CAMAC crates
____ House VME crate
____ MI correction element power supplies and regulators
____ RR correction element power supplies and regulators
____ Abort patch panel and related CAMAC hardware
____ LCW system and the associated PLC
____ VESDA display panel for local readouts

Trainer Date

7. MI-52 Service Building

____ P1 Line extraction Lambertson power supply
____ P1 Line extraction kicker power supply
____ P1 Line electrostatic septa power supply
____ Sextupole power supplies
____ RR to P1 Line Lambertson power supply
____ RR to P1 Line switch magnet power supply
____ MI-52 closed loop LCW system

Trainer	Date

8. MI-60 Service Building

- ____ Upper bend bus power supply
- ____ Power supply loop control hardware
  - ____ Hipot loop
- ____ MI and RR LLRF systems
- ____ MI and RR damper hardware
- ____ MI HLRF
  - ____ Local controls
  - ____ MEIUs
  - ____ Solid-state drivers
  - ____ Modulators
  - ____ Bias supplies
  - ____ Anode supplies
  - ____ 480V breakers
- ____ RR HLRF
  - ____ Local controls
  - ____ MEIUs
  - ____ Solid-state drivers
  - ____ Modulators
  - ____ Anode supply
- ____ NuMI abort MIRF summation chassis
- ____ MECAR VME
- ____ QCL power supply
- ____ MI-60 LCW room
  - ____ Magnet system
  - ____ Cavity system
  - ____ RF system
  - ____ Be able to change the nitrogen bottle that provides LCW pressure
- ____ Lower bend bus power supply
- ____ Quad bus power supply

Trainer	Date

9. F0 Service Building

____ P1 and P2 Line power supplies

____ F0 LCW pump room

Trainer	Date

10. MI-62 Service Building

____ MIBEAM front end

____ RR coasting beam valve controllers