Memorandum

Michael Lindgren
Division Head

Accelerator Division
P.O. Box 500, MS 306
Kirk Road and Pine Street
Batavia, Illinois 60510-5011

Office: 630.840.8409
mlindgre@fnal.gov

Date: November 1, 2019

To: Todd Sullivan

From: Michael Lindgren Paul C Garopato for Michael Lindgren

Re: Approval for Running Beam to MI/Recycler

Safety documentation and procedures for restart of MI/Recycler are now complete and in place. Therefore, you are hereby authorized to run beam to the MI/Recycler.

cc: D. Capista
N. Chelidze
M. Convery
P. Czarapata
T. Kobilarcik
S. McGimpsey
D. Morris
M. Schoell

Fermilab

ADAP-11-0001
REV. 8

SYSTEM START-UP SIGN-OFF

The signatures below, unless noted in the comments section, indicate that the relevant systems are ready for the restart of beam operation. Indicate in the comments section any remaining work that would affect the restart of beam operations. Indicate N/A for departments that did not do any work on the system.

SYSTEM BEING SIGNED OFF: (Circle as Applicable)
Linac NIF MTA **Booster [8-GeV Line-MI-10 Region]**
(MI-20-MI-62/Recycler) **BNB NuMI P1-P2 Muon P3-Switchyard**
Meson Primary MT MC NM FAST PIP-II _____

DEPARTMENT	DATE	SIGNATURE (Department Head/Designee)
1. Controls	10/28/19	James Patrick
2. Cryogenics	N/A	
3. E/E Support	10.30.2019	Steve Hays
4. RPO Manager	11/1/2019	Madelyn Schnell
5. LSO	N/A	
6. External Beamlines	10/31/2019	DCoglizer
7. Instrumentation	10/18/2019	Eric Prebys
8. Interlocks	11/1/19	Greg W. Bohlen
9. Main Injector	10/31/19	David Capista
10. Mechanical Support	10/31/2019	M Wong-Squires
11. Muon	N/A	
12. Operations	11/01/19	Todd Sullivan
13. Proton Source	N/A	
14. RF	10/31/19	John Reid
15. ENG Support	11/1/19	Paul C Garospato
16. Target Systems	N/A	
17. Shutdown Coordinator	10/31/19	

Comments and special conditions (please mark comment with department # to connect comment with appropriate department):

The MAIN INJECTOR + RECYCLER radiation shielding meets the requirements documented in the 2018 "MAIN INJECTOR 1500 kW INCREMENTAL SHIELDING ASSESSMENT AND 2018 "RECYCLER RING INCREMENTAL - 2.25 × 10^17 PROTONS/HR shielding assessment.

FINAL APPROVALS

System Department Head David Capista Date 11/1/19
Assigned RSO [signature] Date 11/1/19
AD Division Head Paul C Garospato for Michael Sandgren Date 11/1/19

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BEAM PERMIT
11/1/2019

Main Injector Accelerator Safety Envelope (ASE) Limit

The maximum beam intensity transmitted through the Main Injector Beamline is limited to:
7.45×10^{17} protons/hr at 8 GeV
7.45×10^{17} protons/hr at 120 GeV
6.23×10^{17} protons/hr at 150 GeV

No accelerator or beam line will transmit beam without an operational beam interlock safety system.

Main Injector Beamline Operating Limits

The maximum beam intensity transmitted through the Main Injector Beamline is limited to:

2.93×10^{17} protons per hour at 8 GeV
2.93×10^{17} protons per hour at 120 GeV
2.34×10^{17} protons per hour at 150 GeV

Examples:

#1 1,200 pulses per hour at 2.44×10^{14} protons per pulse = 2.93×10^{17} protons per hour at 8 GeV
#2 2,700 pulses per hour at 1.08×10^{14} protons per pulse = 2.93×10^{17} protons per hour at 120 GeV
#3 2,400 pulses per hour at 9.75×10^{13} protons per pulse = 2.34×10^{17} protons per hour at 150 GeV

Special conditions and comments:

Reviewed by Todd Sullivan 11/01/19
Operations Department Head

Reviewed by David Capista 11/1/19
Systems Department Head

Reviewed by [signature] 11/1/19
Assigned RSO

Reviewed by Madelyn Schoell 11/1/2019
ESH&Q Radiation Physics Operations Department Head

Approved by Paul C Garapati for Michael Lindgren 11/1/2019
Accelerator Division Head

Operator Signatures

Crew Chiefs

Crew A

Crew B

Crew C

Crew D

Crew E

Other

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Running Condition
Main Injector

November 1, 2019

Area RSO: Sue McGimpsey

Mode of Operation Full Operation

Beam Limits

Beam Energy	ASE Limit	Operating Limit
8 GeV*	7.45 E17 protons/hr	2.93 E17 protons/hr
120 GeV	7.45 E17 protons/hr	2.93 E17 protons/hr
150 GeV**	6.23 E17 protons/hr	2.34 E17 protons/hr

* Although energy scaling of 8 GeV intensity could be substantially higher, there is no need for higher intensity at 8 GeV and the limit is chosen to match the 120 GeV intensity limit.

** 150 GeV beam operation is for MI studies only. Beam aborted to MI-40 Abort.

Critical Devices I:LAM10 & I:BS10

Coasting beam critical devices are I:BV619 & I:BV622 which are open to achieve coasting beam

Enclosures Protected MI-20--MI-62, TeV F Sector, MI/TeV Crossovers, MI-31 Stub

Preferred Monitoring Devices* Intensity is monitored via I:TOR852 via $10 for Booster to MI, and R:TOR905 via $F3 for RR to MI. Minimize the MI-40 abort Lambertson losses by monitoring via the acknowledgeable alarm.

*Other methods of monitoring intensity may be used.

Requirements

Access Devices I:LAM10 and I:BS10 must be disabled in order to access the enclosures protected. Access is also dependent on Recycler critical devices.

Cool Off Period none

Special Interlocks The CDC Inputs including failure mode devices may all be found on the Safety System Status pages.

Special Concerns Any work performed on critical devices or obtaining a critical device key requires prior RSO approval.

Access to MI-40 Absorber room requires prior RSO approval. RCTs may obtain MI-40 Absorber room key without prior RSO approval.

Gates, Fencing and Passive Shielding Requirements There is no access to radiologically fenced areas without prior RSO approval.

The A150 & P150 ODH barrier gates have been locked in the open position since the shielding physically provides the barrier and isolates the Tevatron from the Main Injector. Shielding, fencing and posting is in accordance with 2018 "Main Injector 1500 kW incremental shielding assessment."

Assigned RSO approval also signifies that all necessary Interlock Tests have been completed and Removable Shielding is installed.

SYS
~~Ops.~~ Dept. Head Approval David Capista 11/1/19

Assigned RSO Approval

OPS
~~Sys.~~ Dept. Head Approval Todd Koba 11/01/19

AD Head Approval Paul C Garcipita for Michael Lindgren

Operational Comments

MCR must be appropriately staffed according to the Accelerator Safety Envelope.

Defense-in-Depth Controls

The Main Injector and Recycler rings utilize defense-in-depth controls to reduce the probability, duration, and likelihood of beam loss accident conditions. These consist of Beam Loss Monitors, Vacuum Interlocks and Power Supply Regulation and Permit Interlocks connected to the Beam Permit System, LCW radiation monitors, Beam Switch Sum Box (BSSB), Time Line Generator (TLG), Main Injector/Recycler Transfer Permit, Main Injector/Recycler Orbit Controls and software Alarms and Limits.

The Beam Permit System, Beam Switch Sum Box (BSSB), Time Line Generator (TLG), Main Injector/Recycler Transfer Permit and the LCW Chipmunk Detectors are required to be operational when the Main Injector or Recycler rings are transporting or accelerating beam.

Individual inputs to the beam permit system from the Beam Loss Monitors, Vacuum Interlocks and Power Supply Regulation and Permit Interlock may be masked on an as needed basis under the direction of the MI Department. Any inputs masked from these three systems and any administrative controls directed by the MI Department are required to be logged in the MCR E-log.

Fermilab

Running Condition
Main Injector

November 1, 2019

Area RSO — Sue McGimpsey

Instrument Information

Interlocked detectors (i.e., Chipmunk, FOX, Scarecrow, TLM, etc.) in "Integrate" mode that trip will not allow a safety system reset until sufficient time has passed to keep the hourly dose rate equal to or below the trip point setting. Interlocked detectors in "Integrate" mode that trip may be reset as the safety system allows. If there are more than ten trips by an interlocked detector in "Integrate" mode in one hour, RSO approval is required before reset.

MUX	Type	Location	QF	R/I Mode	Trip Level	CDC	Device(s) Tripped
1-136	Chipmunk	MI-10 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-160	Chipmunk	MI-20 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-169	Chipmunk	MI-30 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-186	Chipmunk	MI-40 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-192	Chipmunk	MI-50 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-200	Chipmunk	MI-52 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-216	Chipmunk	MI-62 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-208	Chipmunk	MI-60 S Room 117 Pipe & BUS Pen	5	Integrate	5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-209	Chipmunk	MI-60 S Room 110 LCW Pens RF Gal	5	Integrate	5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-210	Chipmunk	MI-60 N Room 110 LCW Pens RF Gal	5	Integrate	5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-211	Chipmunk	MI-60 N Room 118 LCW Pen	5	Integrate	5 mrem/hr	I:MICRD	I:LAM10 & I:BS10
1-212	Chipmunk	MI-60 N Room 118 Pen	5	Integrate	5 mrem/hr	I:MICRD	I:LAM10 & I:BS10

Note: QF only included for chipmmunks

Fermilab

Running Condition
Main Injector

November 1, 2019

Area RSO — Sue McGimpsey

Operator Signatures

Crew Chiefs

Crew A

Crew B

Crew C

Crew D

Crew E

Other

Fermilab

BEAM PERMIT
11/1/2019

Recycler Accelerator Safety Envelope (ASE) Limit

The maximum beam intensity transmitted through the Recycler Beamline is limited to:
1.27×10^{18} protons/hr at 8 GeV

No accelerator or beam line will transmit beam without an operational beam interlock safety system.

Recycler Beamline Operating Limits

The maximum beam intensity transmitted through the Recycler Beamline is limited to:

2.25×10^{17} protons per hour at 8 GeV

Examples: Charge/hr = number of pulses/hr x number of protons/pulse

#1 1,440 pulses per hour at 1.56×10^{14} protons per pulse = 2.25×10^{17} protons per hour.

#2 720 pulses per hour at 3.13×10^{14} protons per pulse = 2.25×10^{17} protons per hour.

Special conditions and comments:

Reviewed by Todd Sidler 11/01/19
Operations Department Head

Reviewed by David Capista 11/1/19
Systems Department Head

Reviewed by [signature] 11/1/19
Assigned RSO

Reviewed by Madeleine Schmitt 11/1/2019
ESH&Q Radiation Physics Operations Department Head

Approved by Paul C Garaffo for Michael Lindgren 11/1/2019
Accelerator Division Head

Operator Signatures

Crew Chiefs

Crew A

Crew B

Crew C

Crew D

Crew E

Other

Fermilab

Running Condition
Recycler

November 1, 2019

Area RSO: Sue McGimpsey

Mode of Operation Transferred Beams

Beam Limits	Beam Energy	ASE Limit	Operating Limit
	8 GeV	1.27 E18 protons/hr	2.25 E17 protons/hr

Critical Devices R:LAM10 & R:BS10

Coasting beam critical devices are CBV621A & CBV621B which are open to achieve coasting beam

Enclosures Protected MI-20--MI-62, TeV F Sector, MI/TeV Crossovers, MI-31 Stub

Preferred Monitoring Devices* Intensity is monitored via R:TOR853 on the $BE event

*Other methods of monitoring intensity may be used.

Requirements

Access Devices R:LAM10 and R:BS10 must be disabled in order to access the enclosures protected. Access is also dependent on Main Injector critical devices.

Cool Off Period none

Special Interlocks The CDC Inputs including failure mode devices may all be found on the Safety System Status pages.

Special Concerns Any work performed on critical devices or obtaining a critical device key requires prior RSO approval.

Access to MI-40 Absorber room requires prior RSO approval. RCTs may obtain MI-40 Absorber room key without prior RSO approval.

Gates, Fencing and Passive Shielding Requirements There is no access to radiologically fenced areas without prior RSO approval.

The A150 & P150 ODH barrier gates have been locked in the open position since the shielding physically provides the barrier and isolates the Tevatron from the Main Injector. Shielding, fencing and posting is in accordance with 2012 "Recycler Ring incremental shielding assessment 2.25E17 protons/hr.

Assigned RSO approval also signifies that all necessary Interlock Tests have been completed and Removable Shielding is installed.

Ops. Dept. Head Approval Todd Sidwell 11/01/19 **Assigned RSO Approval** D M Sempsey

Sys. Dept. Head Approval David Capista 11/1/19 **AD Head Approval** Paul C Garoppolo for Michael Lindgren

Operational Comments

MCR must be appropriately staffed according to the Accelerator Safety Envelope.

Defense-in-Depth Controls

The Main Injector and Recycler rings utilize defense-in-depth controls to reduce the probability, duration, and likelihood of beam loss accident conditions. These consist of Beam Loss Monitors, Vacuum Interlocks and Power Supply Regulation and Permit Interlocks connected to the Beam Permit System, LCW radiation monitors, Beam Switch Sum Box (BSSB), Time Line Generator (TLG), Main Injector/Recycler Transfer Permit, Main Injector/Recycler Orbit Controls and software Alarms and Limits.

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Individual inputs to the beam permit system from the Beam Loss Monitors, Vacuum Interlocks and Power Supply Regulation and Permit Interlock may be masked on an as needed basis under the direction of the MI Department. Any inputs masked from these three systems and any administrative controls directed by the MI Department are required to be logged in the MCR E-log.

Fermilab

Running Condition
Recycler

November 1, 2019

Area RSO — Sue McGimpsey

Instrument Information

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1-160	Chipmunk	MI-20 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-169	Chipmunk	MI-30 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-186	Chipmunk	MI-40 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-192	Chipmunk	MI-50 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-200	Chipmunk	MI-52 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-216	Chipmunk	MI-62 SB LCW	1	Integrate	2.5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-208	Chipmunk	MI-60 South Rm 117 Pipe & BUS Pen.	5	Integrate	5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-209	Chipmunk	MI-60 S Room 110 LCW Pens RF Gal	5	Integrate	5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-210	Chipmunk	MI-60 N Room 110 LCW Pens RF Gal	5	Integrate	5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-211	Chipmunk	MI-60 N Room 118 LCW Pen	5	Integrate	5 mrem/hr	I:MICRD	R:LAM10 & R:BS10
1-212	Chipmunk	MI-60 N Room 118 Pen	5	Integrate	5 mrem/hr	I:MICRD	R:LAM10 & R:BS10

Note: QF only included for chipmmunks

Running Condition
Recycler

November 1, 2019

Area RSO: Sue McGimpsey

Operator Signatures

Crew Chiefs

Crew A

Crew B

Crew C

Crew D

Crew E

Other