ACCELERATOR DIVISION ADMINISTRATIVE PROCEDURE

ADAP-11-0003

APPROVED ACCELERATOR BEAM INTENSITY OPERATING LIMITS

RESPONSIBLE DEPARTMENT: ADESH

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1.0 PURPOSE AND SCOPE

In accordance with the DOE Accelerator Safety Order, DOE O 420.2C, and as flowed down through the Fermilab Director's Policies, the Fermilab Environment Safety and Health Manual including the Fermilab Radiological Control Manual, this procedure defines the approved accelerator beam intensity operating limits derived from the various radiological shielding assessments.

The table in Section 2 specifies the beam power limitations for each section of the Fermilab accelerator complex. The shielding assessments conducted for each beamline or experimental area with respect to the FRCM limits found that continuous operation at an intensity defined in the Operating Intensity Limits along with the stated Beam Energy is safe and defines the normal Beam Permit operating limits.

The Basis listed in the table identifies what limits the beam intensity for each area. The term "Overburden" is used in the table when the Operating Intensity is limited by the shielding surrounding the beamline enclosure. The overburden intensity limits are specified in protons per hour since the concern here is prompt radiation exposures from beam operations. The term "Groundwater" is used when the intensity is limited to the number of particles where activation of unprotected soil surrounding the enclosures leads to radioactivity in the ground water. Ground water limits are cumulative effects and are expressed in protons per year.

2.0 BEAM INTENSITY OPERATING LIMITS

Area	Operating Intensity Limits	Beam Energy	Basis
Linac to NTF	6.70 E17 protons/hour	66 MeV	Overburden [i, ii]
Linac	3.54 E17 protons/hour	400 MeV	Overburden [i]
Linac Absorber #1	6.40 E20 protons/year	400 MeV	Groundwater [iii]
Linac Absorber #2	6.40 E20 protons/year	400 MeV	Groundwater [iii]
MuCool Test Area to Emittance Absorber (Emittance Mode)	9.60 E15 protons/hour	400 MeV	Overburden [iv]
MuCool Test Area to Final Beam Absorber (Experiment Mode)	9.60 E14 protons/hour	400 MeV	Overburden [iv]
MuCool Test Area Final Beam Absorber	7.75 E19 protons/year	400 MeV	Groundwater [iv]

Area	**Operating Intensity Limits**	**Beam Energy**	**Basis**
Booster & 8 GeV Line up to cell 803	1.80 E17 protons/hour	8 GeV	Overburden [v]
Booster 8 GeV Absorber	6.90 E19 protons/year	8 GeV	Groundwater [v]
8 GeV Line from cell 803 to cell 850	2.84 E17 protons/hour	8 GeV	Overburden [vi]
8 GeV Line from cell 850 to the Booster Neutrino Beam Target Station	1.62 E17 protons/hour	8 GeV	Overburden [vi]
Booster Neutrino Beam Target Station	7.50 E20 protons/year	8 GeV	Groundwater [vii]
Main Injector	1.39 E17 protons/hour*	8 GeV	Overburden [viii]
Main Injector	1.39 E17 protons/hour	120 GeV	Overburden [viii]
Main Injector	1.16 E17 protons/hour	150 GeV	Overburden [viii]
MI-40 Abort	2.09 E21 protons/year	8, 120 & 150 GeV	Groundwater [viii, ix]
Recycler	2.25 E17 protons/hour	8 GeV	Overburden [ix]
NuMI	1.46 E17 protons/hour	120 GeV	Overburden [x]
NuMI Target Station	2.14 E21 protons/year	120 GeV	Groundwater [x]
Main Injector to Muon Campus	3.60 E13 protons/hour	8 GeV	Overburden [xi]
Main Injector to Muon Campus AP0 Target	1.80 E16 protons/hour	120 GeV	Overburden [xi]
AP0 Target Station	7.27 E20 protons/year	120 GeV	Groundwater [xii]
Beam to the Switchyard 120 Beamlines including Meson Test (P3 line, SY120 interconnect region, and the SY 120 beamline in enclosures B and C), M01-M05	2.50 E15 protons/hour	120 GeV	Overburden [xiii]

Area	Operating Intensity Limits	Beam Energy	Basis
Beam to the Switchyard Absorber	2.98 E17 protons/year	120 GeV	Groundwater [xiii]
M01 Target Train	7.94 E17 protons/year	120 GeV	Groundwater [xiii]
M02 Absorber	1.74 E17 protons/year	120 GeV	Groundwater [xiii]
M03 Pinhole Collimator	1.74 E17 protons/year	120 GeV	Groundwater [xiii]
Meson Center beam from M01-M05 and MC6	6.00 E12 protons/hour	120 GeV	Overburden [xiv]
MC6 Target Pile	5.26 E16 protons/year	120 GeV	Groundwater [xiv]
Neutrino Experimental Area	6.00 E14 protons/hour	120 GeV	Overburden [xv]
NM3 Target Station	1.75 E21 protons/year	120 GeV	Groundwater [xv]
A0 Photoinjector	2.88 E17 electrons/hour	25 MeV	Overburden [xvi]
Advanced Superconducting Test Accelerator (ASTA) Injector	1.96 E17 electrons/hour	55 MeV	Overburden [xvii]

* It is noted that although energy scaling of the 8 GeV intensity could be substantially higher, there is no operational need for a higher 8 GeV intensity. Therefore, the 8 GeV intensity limit has been chosen to match the 120 GeV intensity limit.

3.0 DISTRIBUTION

An electronic controlled copy of this procedure is maintained on the ESH Department website at: http://ad-esh.fnal.gov/ad_adap.html

An uncontrolled copy is provided to the Fermi Site Office.

4.0 REFERENCES

[i] **Memo, "Completion of the Linac Shielding Assessment and Verification of Operation at Full Intensity"**, from G. Dugan to D. Cossairt, page 2, June 28, 1991. **Radiation Shielding Assessment of the Linac High Energy Enclosure Following the 1993 Upgrade Installation and Low Intensity Commissioning**, Charles Schmidt and Thomas Kroc, September 21, 1993.

[ii] **Neutron Therapy Facility 1992 Shielding Assessment**, Arlene J. Lennox, April 10, 1992.

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[iv] **MuCool Facility Shielding Assessment,** C. Johnstone, I. Rakhno, N. Mokhov, W. Higgins, November 1, 2010.

[v] **1998 Booster Shielding Assessment**, Robert C. Webber, page B.1, March 4, 1999.

[vi] **8 GeV Fixed Target Shielding Assessment,** C. Moore, page 1, April 19, 2002. **8GeV Line and MiniBooNE Nova-Era Operational Limits**, Michael A. Gerardi, March 10, 2010.

[vii] **MiniBooNE Target Station Shielding Assessment**, P. Kasper, J. Link, and P. Martin, August 2, 2002. **Addendum to the MiniBooNE Target Station Shielding Assessment**, P. Kasper, R. Zimmermann, and B. Higgins, June 18, 2004.

[viii] **Main Injector Incremental Shielding Assessment 700 kW,** Wayne A. Schmitt, William S. Higgins, Michael C. Vincent, Roger Zimmermann, August 2012.

[ix] **Recycler Ring Incremental Shielding Assessment 2.25 x10^{17} protons/hour**, Wayne A. Schmitt, William S. Higgins, Michael C. Vincent, Roger Zimmermann, October 3, 2012.

[x] N. Grossman, **NuMI Beam Line & MINOS Hall Shielding Assessment**, July 2004. K. Vaziri, **Addendum to NuMI Shielding Assessment**, June 2007. Bob Ducar, Jim Hylen, Andy Stefanic, **Collection of condensate from NuMI chase re-circulating air cooling system**, February 7, 2007. K. Vaziri, **Radiological issues associated with venting tritiated air from NuMI SR3**, February 12, 2007. Michael A. Gerardi, **Safety Envelope for NuMI Operation**, March 28, 2007. K. Vaziri, **Addendum to NuMI Shielding Assessment**, October 2007. K. Vaziri, **Tritium Release from NuMI MI-65 Stack**, April 16, 2007. K. Vaziri, **Radiological issues associated with helium in the NuMI Decay Pipe at 500 kW**, October 2007. **Neutrino at Main Injector (NuMI) Beam Line Shielding Assessment for 778 kilowatt (kW) Operation of Neutrino Off-axis Electron Neutrino (νe) Appearance (NOvA) Experiment**, K. Vaziri, February 2013.

[xi] **Antiproton Source 2000 Shielding Assessment,** Pbar Source Department, page 1, June 2000.

[xii] **EP Note #8,** J. Donald Cossairt, page 17, December 1, 1994. **EP Note #17,** J. Donald Cossairt, A. J. Elwin, P. Kesich, A. Malensek, N. Mokhov, and A. Wehmann June 24, 1999. **Shielding Calculations for the AntiProton Target Area,** J. D. Cossairt and P. Yurista, TM-1136, page 2, September 1982. **AP0 Target Station Review Committee Report**, Carlos Hojvat, Bill Freeman, Fritz Lange, Tony Leveling, Anthony Malensek, page 10, June 9, 1997.

[xiii] **2003 Shielding Assessment for the Switchyard 120 Project**, C. Brown, T. Kobilarcik, G. Koizumi, E. Ramberg, and W. Higgins, April 8, 2003.

[xiv] **Addendum to the SY 120 Shielding Assessment to add the MCenter branch to the beam line**, C. Brown and D. Jensen, February 5, 2004. **Addendum to the SY 120 Shielding Assessment for Continued Operation of the Meson Center Beam Line**, Thomas R Kobilarcik and Wayne Schmitt, November 25 2013.

[xv] **Neutrino Muon Beam Line Shielding Assessment**, Thomas R. Kobilarcik and Michael Geelhoed, February 24, 2012.

[xvi] **A0 Photoinjector SAD**, H. Edwards, page 4, April 1997.

[xvii] **Shielding Assessment for the Advanced Superconducting Test Accelerator (ASTA) injector**, M. Church, I. Rakhno, E. Harms, December 12, 2014.