MESON SWITCHYARD 120 EXPERIMENTAL AREAS

SECTION IV CHAPTER 03 OF THE FERMILAB SAD

Revision 2 January 16, 2024

This Chapter of the Fermilab Safety Assessment Document (SAD) contains a summary of the results of the Safety Analysis for the Meson Switchyard 120 Experimental Area of the Fermilab Main Accelerator that are pertinent to understanding the risks to the workers, the public, and the environment due to its operation.

SAD Chapter Review

This Section 4, Chapter 3 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD), *Meson Switchyard 120 Experimental Areas*, was prepared and reviewed by the staff of the Particle Physics Directorate, Detector Development and Operations Department in conjunction with the Environment, Safety & Health Division (ESH) Accelerator Safety Department.

Signatures below indicate review of this Chapter, and recommendation that it be approved and incorporated into the Fermilab SAD.

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Revision History

Printed versions of this Chapter of the Fermilab Safety Assessment Document (SAD) may not be the currently approved revision. The current revision of this Chapter can be found on ESH DocDB #1066 along with all other current revisions of all Chapters of the Fermilab SAD.

Author	Rev. No.	Date	Description of Change
Evan Niner	2	January 16, 2024	• Update to match new SAD Layout • Incorporate Risk Matrix and hazard discussion • Removed NM4/e1039 discussion to dedicated chapter
Eric McHugh	1	January 15, 2017	Updated PPD Experimental ORC Procedure to FESHM 2005 ORC
Eric McHugh	0	August 28, 2016	Initial Release of the Fermilab Meson and Neutrino Switchyard 120 Experimental Areas Chapter for the Fermi National Accelerator Safety Assessment Document (SAD)

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Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
ACNET	Accelerator Control Network System
AD	Accelerator Directorate
AHJ	Authority Having Jurisdiction
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
APS-TD	Applied Physics and Superconducting Technology Directorate
ARA	Airborne Radioactivity Area
ASE	Accelerator Safety Envelope
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASO	Accelerator Safety Order, referring to DOE O 420.2D *Safety of Accelerators*
^{7}Be	Beryllium-7
BLM	Beam Loss Monitor
BNB	Booster Neutrino Beam
BPM	Beam Position Monitor
BY	Boneyard
CA	Controlled Area
CA	Contamination Area
CAS	Contractor Assurance System
CC	Credited Control
CCL	Coupled Cavity Linac
CDC	Critical Device Controller
CERN	European Organization for Nuclear Research
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations (United States)
Ci	Curie
CLW	Co-Located Worker (the worker in the vicinity of the work but not actively participating)
cm	centimeter
CPB	Cryogenics Plant Building
CSO	Chief Safety Officer
CUB	Central Utility Building
CW	Continuous Wave

CX	Categorically Excluded
D&D	Decontamination and Decommissioning
DA	Diagnostic Absorber
DAE	Department of Atomic Energy India
DCS	Derived Concentration Standard
DocDB	Document Database
DOE	Department of Energy
DOT	Department of Transportation
DR	Delivery Ring
DSO	Division Safety Officer
DSS	Division Safety Specialist
DTL	Drift Tube Linac
DUNE	Deep Underground Neutrino Experiment
EA	Environmental Assessment
EA	Exclusion Area
EAV	Exhaust Air Vent
EENF	Environmental Evaluation Notification Form
EMS	Environmental Management System
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ES&H	Environment, Safety and Health
Fermilab	Fermi National Accelerator Laboratory, see also FNAL
FESHCom	Fermilab ES&H Committee
FESHM	Fermilab Environment, Safety and Health Manual
FHS	Fire Hazard Subcommittee
FIRUS	Fire Incident Reporting Utility System
FNAL	Fermi National Accelerator Laboratory, see also Fermilab
FODO	Focus-Defocus
FONSI	Finding of No Significant Impact
FQAM	Fermilab Quality Assurance Manual
FRA	Fermi Research Alliance
FRCM	Fermilab Radiological Control Manual
FSO	Fermilab Site Office
FW	Facility Worker (the worker actively performing the work)
GERT	General Employee Radiation Training
GeV	Giga-electron Volt
^{3}H	Tritium
HA	Hazard Analysis

HAR	Hazard Analysis Report
HCA	High Contamination Area
HCTT	Hazard Control Technology Team
HEP	High Energy Physics
HFD	Hold for Decay
HLCF	High Level Calibration Facility
HPR	Highly Protected Risk
Hr	Hour
HRA	High Radiation Area
HSSD	High Sensitivity Air Sampling Detection
HVAC	Heating, Ventilation, and Air Conditioning
HWSF	Hazardous Waste Storage Facility
Hz	Hertz
IB	Industrial Building
IBC	International Building Code
ICW	Industrial Cooling Water
IEPA	Illinois Environmental Protection Agency
IEEE	Institute of Electrical and Electronics Engineers
INFN	Istituto Nazionale di Fisica Nucleare
IMPACT	Integrated Management Planning and Control Tool
IPCB	Illinois Pollution Control Board
IQA	Integrated Quality Assurance
ISD	Infrastructure Services Division
ISM	Integrated Safety Management
ITNA	Individual Training Needs Assessment
KeV	kilo-electron volt
kg	kilo-grams
kW	kilo-watt
LBNF	Long Baseline Neutrino Facility
LCW	Low Conductivity Water
LHC	Large Hadron Collider
LLCF	Low Level Calibration Facility
LLWCP	Low Level Waste Certification Program
LLWHF	Low Level Waste Handling Facility
LOTO	Lockout/Tagout
LPM	Laser Profile Monitor
LSND	Liquid Scintillator Neutrino Detector
LSO	Laser Safety Officer

m	meter
mA	milli-amp
MABAS	Mutual Aid Box Alarm System
MARS	Monte Carlo Shielding Computer Code
MC	Meson Center
MC&A	Materials Control and Accountability
MCR	Main Control Room
MEBT	Medium Energy Beam Transport
MEI	Maximally Exposed Individual
MeV	Mega-electron volt
MI	Main Injector
MINOS	Main Injector Neutrino Oscillation Search
MMR	Material Move Request
MOI	Maximally-Exposed Offsite Individual *(Note: due to the Fermilab Batavia Site being open to the public, the location of the MOI is taken to be the location closest to the accelerator that is accessible to members of the public.)*
MP	Meson Polarized
mrad	milli-radian
mrem	milli-rem
mrem/hr	milli-rem per hour
MT	Meson Test
MTA	400 MeV Test Area
MTF	Magnet Test Facility
^{22}Na	Sodium-22
NC	Neutrino Center
NE	Neutrino East
NEC	National Electrical Code
NEPA	National Environmental Policy Act
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NM	Neutrino Muon
NMR	Nuclear Material Representative
NOvA	Neutrino Off-axis Electron Neutrino (ve) Appearance
NPH	Natural Phenomena Hazard
NRTL	Nationally Recognized Testing Laboratory
NIF	Neutron Irradiation Facility
NTSB	Neutrino Target Service Building, see also TSB
NuMI	Neutrinos at the Main Injector

NW	Neutrino West
ODH	Oxygen Deficiency Hazard
ORC	Operational Readiness Clearance
OSHA	Occupational Safety and Health Administration
pCi	pico-Curie
pCi/mL	pico-Curie per milliliter
PE	Professional Engineer
PIN	Personal Identification Number
PIP	Proton Improvement Plan
PIP-II	Proton Improvement Plan - II
PHAR	Preliminary Hazards Analysis Report
PPD	Particle Physics Directorate
PPE	Personnel Protective Equipment
QA	Quality Assurance
QAM	Quality Assurance Manual
RA	Radiation Area
RAF	Radionuclide Analysis Facility
RAW	Radioactive Water
RCT	Radiological Control Technician
RF	Radio-Frequency
RFQ	Radio-Frequency Quadrupole
RIL	RFQ Injector Line
RMA	Radioactive Material Area
RMS	Root Mean Square
RPCF	Radiation Physics Calibration Facility
RPE	Radiation Physics Engineering Department
RPO	Radiation Physics Operations Department
RRM	Repetition Rate Monitor
RSI	Reviewed Safety Issue
RSIS	Radiation Safety Interlock System
RSO	Radiation Safety Officer
RWP	Radiological Work Permit
SA	Shielding Assessment
SAA	Satellite Accumulation Areas
SAD	Safety Assessment Document
SCF	Standard Cubic Feet
SCFH	Standard Cubic Feet per Hour
SEWS	Site-Wide Emergency Warning System

SNS	Spallation Neutron Source
SR	Survey Riser
SRF	Superconducting Radio-Frequency
SRSO	Senior Radiation Safety Officer
SSB	Switchyard Service Building
SSP	Site Security Plan
SWIC	Segmented Wire Ionization Chambers
TLM	Total Loss Monitor
TLVs	Threshold Limit Values
TPC	Time Projection Chamber
TPES	Target Pile Evaporator Stack
TPL	Tagged Photon Lab
TSB	Target Service Building, see also NTSB
TSCA	Toxic Substances Control Act
TSW	Technical Scope of Work
T&I	Test and Instrumentation
UPB	Utility Plant Building
UPS	Uninterruptible Power Supply
USI	Unreviewed Safety Issue
VCTF	Vertical Cavity Test Facility
VHRA	Very High Radiation Area
VMS	Village Machine Shop
VMTF	Vertical Magnet Test Facility
VTS	Vertical Test Stand
WSHP	Worker Safety and Health Program
µs	micro-second

IV-3. Meson Switchyard 120 Experimental Areas

IV-3.1. Introduction

This Section 4, Chapter 3 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD) covers the Meson Switchyard 120 Experimental Areas segment of the Fermilab Main Accelerator.

IV-3.1.1 Purpose/Function

The Fermilab Meson Switchyard 120 Experimental Areas consist of three locations that house detectors that are served by two beam lines. These locations house permanent beam characterization equipment, long-term experiments, and are readily configurable and flexible for research and development for new detectors and detector technology. The meson beam lines deliver either protons or a mixture of mesons and leptons.

The Fermilab Test Beam Facility (FTBF), located along the Fermilab meson line, is comprised of three test areas, including enclosures MT6 Section 1 and MT6 Section 2 in the MTest line, MC7 Section 1 and MC7 Section 2 in the MCenter line, and the M03 High Rate Tracking Area further upstream. The Meson beam line is described in greater detail in SAD Section III Chapter 13 and receives beam from the upstream Switchyard segment. The location of FTBF is shown arially in Figure 2 and a schematic layout in Figure 3. These facilities allow experimenters to expose their equipment to differing beam intensities and energies in order to explore new detector technologies and to characterize and improve existing technologies.

IV-3.1.2 Current Status

The Meson Switchyard 120 Experimental Areas segment of the Fermilab Main Accelerator is currently:

- **Meson Test: Operational**
- **Meson Center 7: Operational**
- **Meson 03 High Rate Tracking Area: Operational**

IV-3.1.3 Description

The FTBF is served by the meson fixed-target beamline and enables experimenters to test their detectors in an active beamline and also to calibrate detectors for other types of research (cosmic rays, etc.). Typically experiments installed at FTBF are operated for short durations (< 1 month in MTest and < 1 year in MCenter). These experiments and tests utilize target materials, charged particle tracking detectors, particle identification detectors and calorimetric detectors. To reduce beam scattering, some experiments use evacuated detector vessels or helium filled pipes to minimize the amount of material in the beam line.

FTBF is housed in the west side of the Meson Detector building. Inside this space are work spaces, storage, a tech shop, offices, and two control rooms. Within this building are beam enclosures MT6 Section 1 and MT6 Section 2 of the MTest beamline where experiments are placed. Beam is terminated in a beam stop after the MT6 Section 2 enclosure. Also from inside FTBF is the access point to MC7 Section 1 and MC7 Section 2 in the MCenter beamline. Beam is terminated in a beam stop after MC7 Section 2.

The M03 High Rate Tracking area is an alcove with an air gap in the beam pipe upstream in section M03 where an experiment can take place as shown in Figure 4. This space is not accessible from inside FTBF but accessed via the M03 service building. M03 is operated by the Accelerator Directorate and all credited controls are accessed in SAD Section III Chapter 13. FTBF manages experiments placed in this space. This SAD chapter will discuss Non-Accelerator Specific Hazards associated with experiments located in this space with the Accelerator Specific Hazards being fully defined in SAD Section III Chapter 13 for M03.

The character of the hazards associated with these planned experiments is similar, but may vary in magnitude, which has been the case with prior experiments, and will likely be the case in the future. New experiments are screened for hazards first through submitting a Technical Scope of Work (TSW) for review and approval by subject matter experts (SMEs) and senior lab management. When the experiment arrives onsite, it is again reviewed prior to operation through the Operational Readiness Clearance (ORC) [2] process coordinated by the ORC chairperson for the respective area prior to approval. Such experiments would be similar in ES&H impact to those described here.

IV-3.1.4 Location

The Meson Switchyard 120 Experimental Areas are located on the Fermilab site in Batavia, IL. This segment of the accelerator complex covers beam enclosures MC7 Section 1, MC7 Section 2, MT6 Section 1, and MT6 Section 2. Additionally, tech shop and experiment staging areas are located on the west side of the Meson Detector building outside the beam enclosures as shown in Figure 3. The M03 beam segment described in chapter III-13 contains an air gap in the beam in an alcove where experiments covered by the FTBF program may be placed.

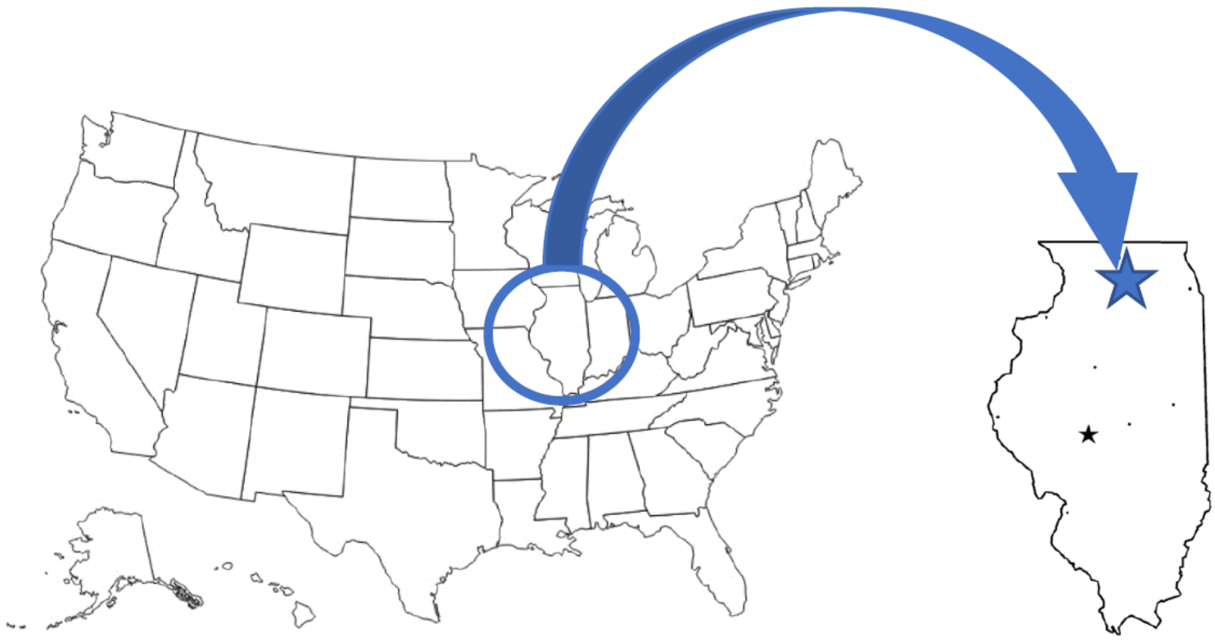

Figure 1. Regional view showing the location of the Fermilab site in Batavia, IL.

The Meson Switchyard 120 Experimental Areas are located northeast of Wilson Hall along Discovery Road in the fixed target area on the Fermilab site.

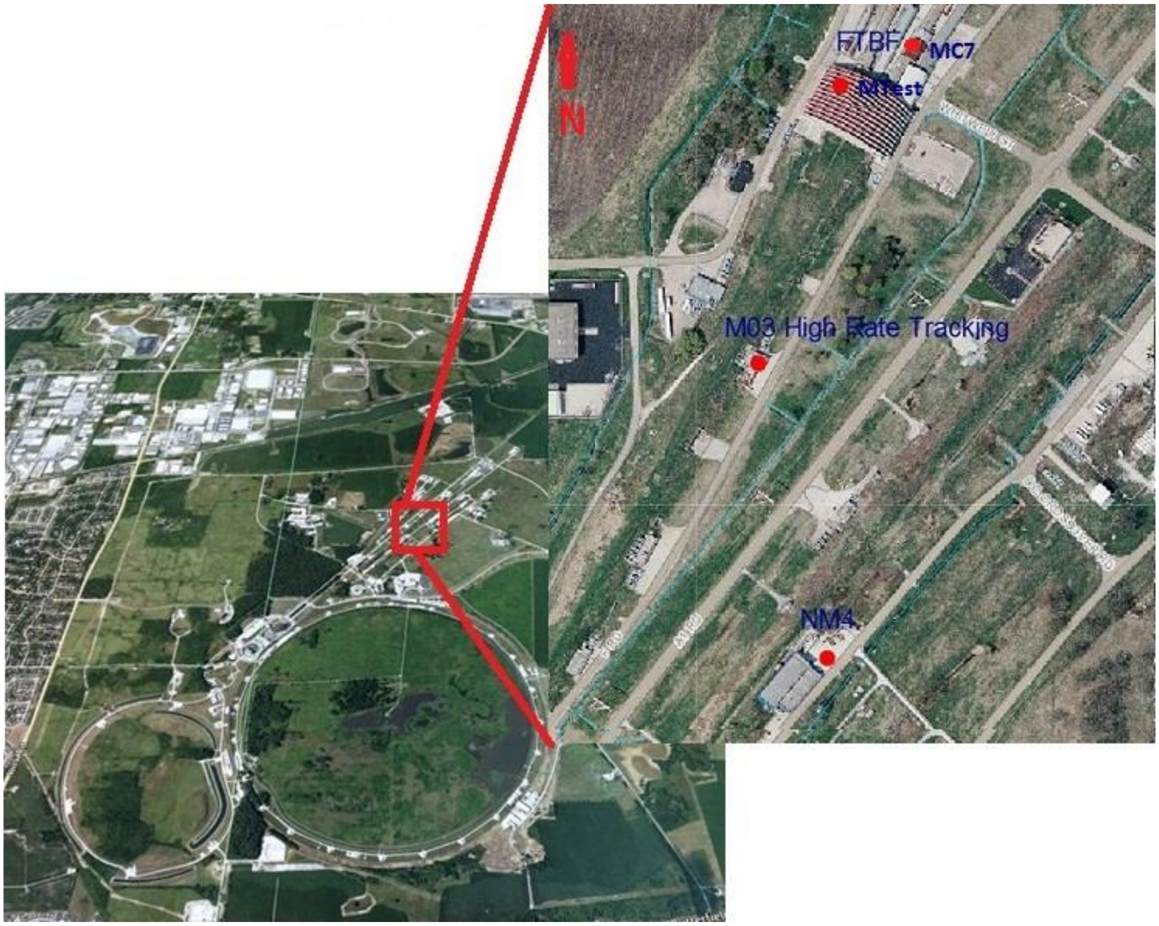

Figure 2. Aerial view of the Fermilab site, indicating the location of the Meson Switchyard 120 Experimental Areas which consist of the M03 High Rate Tracking space and FTBF which contains the MT6.1, MT6.2, and MC7 beam

enclosures in addition to work spaces.

Figure 3. Schematic view inside the FTBF building. Circled in red are enclosures MT6 Section 1 and MT6 Section 2 in the MTest line up top and MC7 Section 1 and MC7 Section 2 in the MCenter line on bottom. Surrounding these enclosures are work spaces and offices for experiment staging.

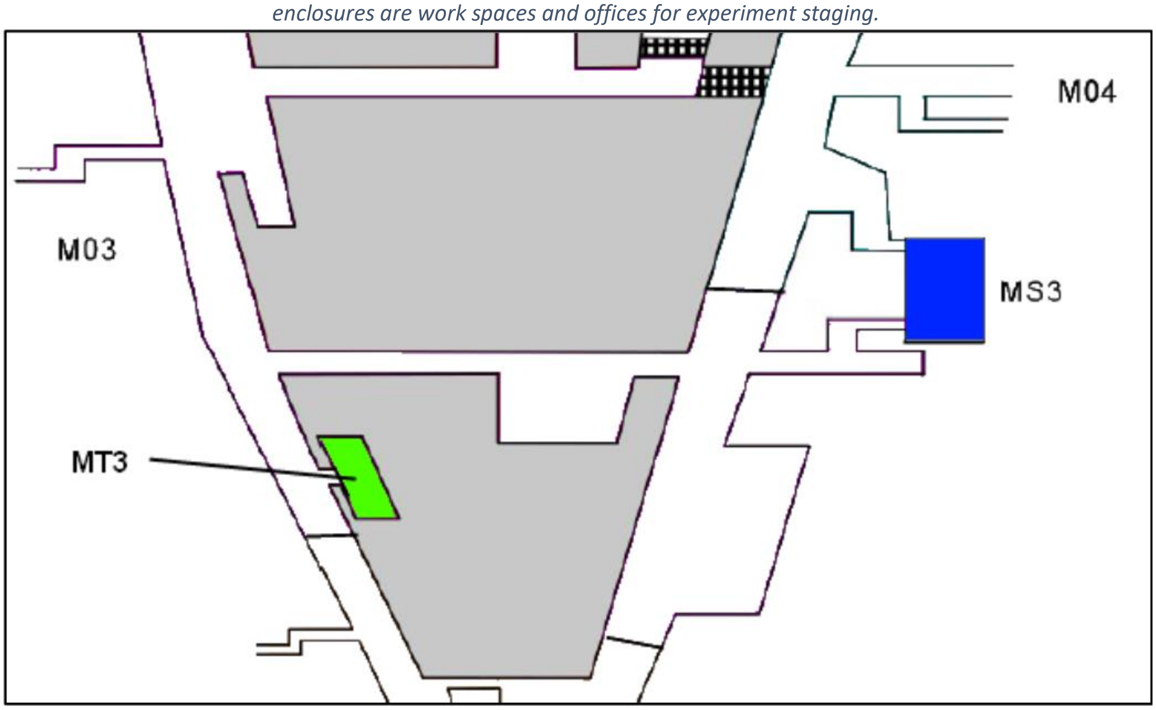

Figure 4. Shown in green is the section of the MTest beamline containing an air gap where experiments may be installed in a location known as the M03 high rate tracking area. Access to this space comes from the MS3 service building shown in blue. This location is upstream of FTBF.

IV-3.1.5 Management Organization

The Meson Switchyard 120 Experimental Areas are managed by the Particle Physics Directorate (PPD). The FTBF has a facility manager and dedicated scientific and technical support staff to schedule and coordinate experiment operations. Facility staff coordinate with the beamline physicist assigned from the External Beams Delivery Department in the Accelerator Directorate (AD) who maintains any AD owned systems, instrumentation, beamlines, and controls that are present in the experimental space.

IV-3.1.6 Operating Modes

The Accelerator Safety Envelope (ASE) [3] limits operating modes of the Fermilab Meson Switchyard 120 Experimental Areas and describes the beam character and beam limitations delivered to these areas.

The M03 High Rate Tracking area is an alcove in the M03 beam enclosure which is described in III-13, Meson Area chapter of the SAD. In this space there is a gap in the beam pipe where an experiment can be placed. This area sees 120 GeV primary proton beam.

The MTest beam enclosures MT6 Section 1 and MT6 Section 2 can receive beam in several compositions. They can receive 120 GeV primary proton beam ("Diffracted Proton Mode"). With the insertion of the MT1 target upstream in the Meson area, they can receive secondary beam of mixed particles (protons, pions, muons, kaons, and electrons) from 60 to 32 GeV ("High Energy Mode"). With the insertion of the MT4 target, they can receive secondary beam from 32 to 1 GeV ("Low Energy Mode"). In both secondary modes, oppositely charged particles are not available simultaneously and there is no provision for neutral particles. Individual species cannot be selected, the experiment is responsible for particle identification.

The MCenter facility can provide secondary beam with positively or negatively charged particles (but not both simultaneously) from 80 to 8 GeV. There is no provision for neutral particles and experiments are responsible for individual particle identification. There are currently two tertiary targets located in MC7 that may be inserted into the beam (not simultaneously) according to the approved run conditions. One target is available in MC7 Section 1 and the other in MC7 Section 2. Both are copper targets housed in a steel collimator to produce tertiary beam at an angle to the incident secondary beam. They are typically paired with a downstream analyzing magnet for momenta selection. These tertiary target stations are further discussed in the post assessments [6][7][8].

IV-3.1.7 Inventory of Hazards

The following table lists all the identified hazards found in the Meson Switchyard 120 Experiment Area enclosures and support buildings. *Appendix C – Non-Accelerator Specific Hazard (NASH) Risk Matrix Tables* describes the baseline risk (i.e., unmitigated risk), any preventative controls and/or mitigative controls in place to reduce the risk, and residual risk (i.e., mitigated risk) for facility worker, co-located worker and Maximally Exposed Offsite Individual (MOI) (i.e., members of the public). A summary of these controls is described within Section I-4.1 *Non-Accelerator Specific Hazards.*

Prompt ionizing radiation and oxygen deficiency hazards due to cryogenic systems within accelerator enclosures have been identified as accelerator specific hazards, and as such, their controls are identified as Credited Controls. The analysis of these hazards and their Credited Controls will be discussed within this SAD Chapter, and their Credited Controls summarized in the Accelerator Safety Envelope for the Main Accelerator. Accelerator specific controls are identified as **purple/bold** throughout this Chapter.

All other hazards present in the Meson Switchyard 120 Experimental Areas are safely managed by other DOE approved applicable safety and health programs and/or processes, and their analyses have been performed according to applicable DOE requirements as flowed down through the Fermilab Environment, Safety and Health Manual (FESHM). These hazards are considered to be Non-Accelerator-Specific Hazards (NASH), and their analysis will be summarized in this SAD Chapter.

Table 1. Hazard Inventory for Meson and Neutrino Switchyard 120 Experiment Area.

Radiological		Toxic Materials	
☒	**Prompt Ionizing Radiation**	☒	Lead
☒	Residual Activation	☒	Beryllium
☒	Groundwater Activation	☐	Fluorinert & Its Byproducts
☒	Surface Water Activation	☒	Liquid Scintillator
☐	Radioactive Water (RAW) Systems	☐	
☒	Air Activation	☐	Ammonia
☐	Closed Loop Air Cooling	☒	Nanoparticle Exposures
☒	Soil Interactions	**Flammables and Combustibles**	
☒	Radioactive Waste	☒	Combustible Materials (e.g., cables, wood cribbing, etc.)
☒	Contamination	☒	Flammable Materials (e.g., flammable gas, cleaning materials, etc.)
☒	Beryllium-7	**Electrical Energy**	
☒	Radioactive Sources	☒	Stored Energy Exposure
☐	Nuclear Material	☒	High Voltage Exposure
☐	Radiation Generating Devices (RGDs)	☒	Low Voltage, High Current Exposure
☒	Non-Ionizing Radiation Hazards	**Kinetic Energy**	

Thermal Energy		☒	Power Tools
☐	Bakeouts	☒	Pumps and Motors
☒	Hot Work	☒	Motion Tables
☒	Cryogenics	☐	Mobile Shielding
Potential Energy		**Magnetic Fields**	
☒	Crane Operations	☒	Fringe Fields
☒	Compressed Gasses	**Other Hazards**	
☒	Vacuum/Pressure Vessels/Pipes	☒	Confined Spaces
☒	Vacuum Pumps	☐	Noise
☒	Material Handling	☒	Silica
Access & Egress		☒	Ergonomics
☒	Life Safety Egress	☐	Asbestos
		☒	Working at heights

IV-3.2. Safety Assessment

All hazards for the Meson Switchyard 120 Experimental Areas segment of the Main Accelerator are summarized in this section, with additional details of the analyses for accelerator specific hazards.

IV-3.2.1 Radiological Hazards

Radiation safety has been carefully considered in the design of the Fermilab Meson Switchyard 120 Experimental Areas. All radiation hazards relating to beam operations safety are the responsibility of the Accelerator Directorate. The Accelerator Directorate, whose facilities includes all beamlines, their shielding, radiation, interlocks, beam surveys, monitors and impact of radiation on the environment, is addressed in SAD Section III Chapter 13 on the Meson Area.

The Meson Switchyard 120 Experimental Areas present radiological hazards in the form of Prompt ionizing radiation, residual activation, groundwater activation, surface water activation, RAW systems, air activation, soil interactions, radioactive waste, contamination, Beryllium-7, radioactive sources, and non-ionizing radiation. Detailed shielding assessments [4][5]and post assessment documents [6][7][8][9] address these hazards and provide a detailed analysis of the facility demonstrating the required shielding, controls and interlocks to comply with the Fermilab Radiological Control Manual (FRCM) [1].

Fermilab protocols require that all personnel and experimenters who work in experimental halls must be trained according to Fermilab Radiological Control Manual (FRCM) Chapter 6 – Training and Qualification. All radiological work, posting, labeling, and monitoring in experimental halls must be conducted in accordance with requirements described in FRCM Chapter 2 – Radiological Standards. All experiments at Fermilab will participate in Fermilab's ALARA (As Low As Reasonably Achievable) program as described in FRCM Chapter 3 – Conduct of Radiological Work.

IV-3.2.1.1 Prompt Ionizing Radiation

Ionizing radiation due to beam loss is a primary concern for beam transported through the Meson Switchyard 120 enclosures. In order to protect workers and the general public, the enclosures and beam pipes are surrounded either by sufficient amounts of shielding (earth, concrete or iron), and/or networks of interlocked radiation detectors to keep any prompt radiation within acceptable levels. Operation of the area conforms to the FRCM to maintain exposures for operating personnel as low as reasonably achievable (ALARA).

This hazard has been evaluated via a Maximum Credible Incident (MCI) analysis that is described in Section III-13.3.1 for the Meson Area beamlines which includes the experimental areas the beam passes through. This analysis specifies that Fermilab uses Credited Controls that flow down to the Accelerator Safety Envelope (ASE) to mitigate the consequences of the MCI to at or below the acceptable dose levels described in SAD Section I Chapter 4. A detailed description of each of the Credited Controls and their function is provided in Section III-13.4. The conclusion of these analyses is that the mitigated dose level associated with prompt ionizing radiation due to beam loss is acceptable.

IV-3.2.1.2 Residual Activation

Positioning detector components in the path of the beam may result in activation of the components. This type of radio-activation is called residual activation. The activation level and quantity of activated material will not be unique relative to other accelerator enclosures at Fermilab.

Residual activation hazards will be managed within the ALARA program established throughout the Fermilab accelerator complex and as prescribed in the FRCM Chapter 3. All potential residual activation hazards are handled operationally as in all other primary beam enclosures. These controls include verification of training, centralized authorization, and key entry. The level of control depends on the level of residual radiation. In most cases, the typical Radiological Work Permit (RWP) as described in FRCM Chapter 3, for accesses will suffice. A job-specific RWP and an ALARA plan will be required for work on any highly activated equipment with a potential individual exposure greater than 200 mrem or potential job exposure greater than 1000 person-mrem. Experimental equipment intended for shipment offsite will be surveyed and handled by trained workers in accordance with FRCM Chapter 4. Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.3 Groundwater Activation

Groundwater activation is estimated in the beamline SAD chapter III-13 for the Meson area]. Post-assessment notes[6][7][8] cover experiment specific conditions in MC7. In all cases the contribution from targets and materials in the beamlines are insignificant. Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.4 Surface Water Activation

Surface water activation is estimated in the beamline SAD chapter III-13 for the Meson area. Post-assessment notes[6][7][8] cover experiment specific conditions in MC7. In all cases the contribution from targets and materials in the beamlines are insignificant. Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.5 Radioactive Water (RAW) Systems

N/A.

IV-3.2.1.6 Air Activation

Air activation is estimated in the beamline SAD chapter III-13 for the Meson area. Post-assessment notes[6][7][8] cover experiment specific conditions in MC7. In FTBF spaces the contribution is insignificant. Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.7 Closed Loop Air Cooling

N/A.

IV-3.2.1.8 Soil Interactions

Soil interactions are estimated in the beamline SAD chapter III-13 for the Meson area. Post-assessment notes[6][7][8] cover experiment specific conditions in MC7. In all cases the contribution from targets and materials in the beamlines are insignificant. Risk matrix Tables 22.1-2.23 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.9 Radioactive Waste

Radioactive waste produced in the course of Meson operations will be managed within the established Radiological Protection Program (RPP) and as prescribed in the Fermilab Radiological Control Manual (FRCM).

Radioactive waste is a standard radiological hazard that is managed within the established Radiological Protection Program (RPP) and as prescribed in the Fermilab Radiological Control Manual (FRCM). Waste minimization is an objective of the equipment design and operational procedures. Although production of radioactive material is not an operational function of the Meson Switchyard 120 Experimental Area, beam loss and, in the case of some beam diagnostics devices, intentional interception of the beam will result in activation of beam line elements. Reuse of activated items will be carried out when feasible. Activated items that cannot be reused will be disposed of as radioactive waste in accordance with the FRCM requirements.

Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.10 Contamination

MTest and MCenter do not have the potential to produce contamination from primary interactions of material with the beam. There is the potential an experiment could request through the TSW and ORC process to bring an item with contamination present on it from another facility to FTBF. Policies regarding use of these items will follow FRCM and coordination with the assigned RSO.

The M03 high-rate tracking area has beam traveling through an air gap around the experiment (M03 alcove) where contamination in the form of Be7 in the air is possible. The area is monitored for contamination in accordance with FRCM. Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.11 Beryllium-7

Beryllium-7 isn't hazardous in the pattern of use at this accelerator segment and no prevention and mitigation is required. The risk summarized in Tables 22.1-22.3 is IV.

IV-3.2.1.12 Radioactive Sources

Radioactive sources are used extensively by experiments for calibration and testing of detectors. Radioactive sources present minimal potential hazards for onsite personnel and negligible hazards off site and are monitored according to FRCM Chapter 11 - Environmental Radiation Monitoring and Control.

Commonly used sources are Co-60, Sr-90, Cs-137, Fe-55 and Ru-106. Radioactive source controls described in the Fermilab Radiological Control Manual include requirements for 1) source accountability records to be maintained by the Environment, Safety and Health (ES&H) Division 2) ES&H Division notification and supervision for changes in use, storage, transfer, disposal or loss, 3) labeling, 4) source cabinets and source monitors responsible for issuing sources to users, and 5) source procurement. Radioactive source monitors and source users must be trained in accordance with requirements set forth in FRCM Chapter 4. Radioactive sources pose a contamination hazard if they are not handled properly. Following policies set forth in FRCM Chapter 4 mitigates the contamination hazard. Risk matrix Tables 22.1-22.3 show there is an unmitigated risk of IV for this hazard and a risk of IV after the listed prevention and mitigation strategies.

IV-3.2.1.13 Nuclear Material

N/A.

IV-3.2.1.14 Radiation Generating Devices (RGDs)

N/A.

IV-3.2.1.15 Non-Ionizing Radiation Hazards

Lasers may be used for alignment or calibration of detectors. It is unlikely that a hazard class 1, 2, or 3A laser used for alignment of equipment would cause an inadvertent injury. On the other hand, hazard class 3B and 4 lasers have a significant potential for causing accidental injuries due to their inherently higher beam power. All laser installations (class 3B or greater) must be reviewed by the Fermilab Laser Safety Officer (LSO) prior to commencement of operations according to FESHM[15] Chapter 4260 – Lasers and are screened through the TSW and ORC process. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Assessment. When present, work involving this hazard implements the controls specified in the common Risk Matrix table. For class 3b and above the unmitigated risk is reduced from I to IV. The unmitigated risk of 3R lasers is III and for class 1 and 2 is IV so no additional mitigation is required and remains at discretion of the LSO. No unique controls are in use.

IV-3.2.2 Toxic Materials

Controlling industrial hygiene hazards is addressed through the application of the relevant OSHA standards and other applicable standards (such as ANSI and ACGIH). The Laboratory employs a professional ES&H staff that monitors industrial hygiene hazards for compliance with the national standards and the FESHM 4000 series requirements. When necessary, the ES&H staff develops additional procedures to mitigate the hazards. Specific hazards are detailed below.

IV-3.2.2.1 Lead

Lead presents a potential exposure hazard from manual handling of un-encased materials. At FTBF lead could come in the form of shielding or be brought by an experiment as a detector component such as a calorimeter. Proposed materials are reviewed through the TSW and ORC process in addition to handling training and painting/sealing exposed material. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from II to IV. No unique controls are in use.

IV-3.2.2.2 Beryllium

Beryllium presents a potential exposure hazard during manual handling of un-encased or the rupture of a beam window. Materials brought by an experiment are evaluated through the TSW and ORC process with appropriate structural analysis depending on the application (ex: beam windows). When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from II to IV. No unique controls are in use.

IV-3.2.2.3 Fluorinert & Its Byproducts

N/A.

IV-3.2.2.4 Liquid Scintillator

There is potential for experiments to bring liquid scintillator to the facility for operations. This liquid scintillator may include toxic additives such as pseudocumene or other dopants. This presents a potential exposure hazard from touching or inhaling. Such materials are evaluated through the TSW and ORC process and placed in secondary containment as determined by an SME. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Assessment. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from III to IV. No unique controls are in use.

IV-3.2.2.5 Ammonia

N/A.

IV-3.2.2.6 Nanoparticle Exposure

There is potential for an experiment to bring nanoparticle material as part of their operations. If the material breaks apart or degrades, this presents a potential inhalation event. All proposed materials are screened through the TSW and ORC process with additional mitigation steps. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from III to IV. No unique controls are in use.

IV-3.2.3 Flammables and Combustibles

Flammable and combustible materials are present in this area and their hazards are detailed below.

IV-3.2.3.1 Combustible Materials

Combustible materials may be present in building materials and in liquid forms brought in as part of experiments. Use of combustible material in the Meson Switchyard 120 Experimental Area is strongly discouraged in favor on non-combustible alternatives. In cases where combustible building materials, such as wood, must be used, they are required to be coated in approved fire-retardant coatings. Combustible liquid use is identified and reviewed during the TSW and ORC review by members of the Industrial Hygiene departments and the Fermilab fire department. All unnecessary combustible materials are removed from beam enclosures and stored in safe areas or disposed of. All combustible material used must adhere to FESHM Chapter 6040.1 - Fire Construction Requirements - Fire Retardant Coatings for Combustible Construction Materials, FESHM Chapter 6040.2 - Fire Construction Requirements - Interior Finish Materials, and FESHM 6020.5 Flammable and Combustible Liquids.

When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.3.2 Flammable Materials

Flammable liquids and gasses may be used by facility equipment or may be brought by experiments for use in their apparatus. Flammable gas and liquid use are identified at the TSW and ORC review process. Their use is subject to approval by subject matter experts from the Industrial Hygiene department and the Fermilab fire department. All flammable gas and liquid use must abide by FESHM 6020.3: STORAGE AND USE OF FLAMMABLE GASES and FESHM 6020.5: FLAMMABLE & COMBUSTIBLE LIQUIDS.

The beam lines in MTest and MCenter are instrumented with multiwire proportional chambers which require a slow trickle of flammable gas (85% Argon/ 15% isobutane). All areas where these chambers are used are monitored by smoke detectors. All piping regulators are clearly marked as carrying flammable gas, and flammable gas bottles are only stored and used in approved areas. All exhaust for flammable gas is vented outside buildings through dedicated vent lines.

When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.4 Electrical Energy

Electrical equipment which can pose electrical energy hazards can be present in the Meson Switchyard 120 Experimental Area. These include power supplies, electrical equipment, and experimental apparatuses which have large internal energy storage, high voltage sources, or can produce large electrical currents. All such equipment is identified, reviewed, and approved in the TSW and ORC process by suitable SMEs before the equipment may be energized. In all cases such equipment must be NRTL listed and unmodified from its original state. If no NRTL equipment exists, the non-NRTL equipment must be inspected and approved by the Fermilab Electrical Authority Having Jurisdiction (AHJ) or designee. All electrical equipment and work thereon must adhere to FESHM 9100: FERMILAB ELECTRICAL SAFETY PROGRAM.

IV-3.2.4.1 Stored Energy Exposure

Equipment with large amounts of stored energy can be present in the Meson Switchyard 120 Experimental Area. These include power supplies and electrical equipment for facility and experimental apparatuses. Equipment brought by an experiment is assessed through the ORC by an SME to ensure it complies with all laboratory standards. Written LOTO procedures are required for any equipment having multiple power sources. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.4.2 High Voltage Exposure

High voltage power supplies are common to facility equipment and experiential apparatuses brought into these facilities. Equipment brought by an experiment is assessed through the ORC by an SME to ensure it complies with all laboratory standards. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.4.3 Low Voltage, High Current Exposure

Two electromagnets are present in MCenter, the MC7AN analyzer magnet in MC7 Section 1 and the Jolly Green Giant (JGG) magnet in MC7 Section 2, and each requires high current power supplies providing 100 A and 1200 A respectively. The 100 A power supply for the MC7AN analyzer magnet is located in the MS4 service building while the 1200 A power supply for the JGG magnet is located in the MS5 service building. All maintenance and upkeep of these power supplies and their power busses carrying the current are performed only by equipment experts.

When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.5 Thermal Energy

MTest/MCenter/M03 have hazards associated with thermal energy. Hot work is performed and cryogenic liquids are used by experiments in these spaces. Details below describe the type of work and hazards associated with them.

IV-3.2.5.1 Bakeouts

N/A.

IV-3.2.5.2 Hot Work

Hot work in MTest/MCenter/M03 may occasionally occur. Examples include welding and grinding. This type of work is not typical at these locations and is performed by trained and authorized personnel. All work will have a Hazard Analysis (HA) and required permits before being performed. Individuals will also have approved training. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.5.3 Cryogenics

M03 has an ODH program detailed in section III-13 Meson Area SAD chapter and is an ODH 1 space. The high rate tracking alcove does not have its own additional risk.

MT6 Section 1, MT6 Section 2, MC7 Section 1, and MC7 Section 2 are all ODH 0 spaces. Users may bring in cryogenic liquids for temporary use in these spaces. This is handled through the TSW and ORC process to ensure any material complies with the ODH posting for the space and are handled appropriately. Therefore, no credited controls are required to mitigate this hazard as the oxygen concentration remains above 19.5%.

Risk Tables 22.13 – 22.15 show an unmitigated risk of IV for this hazard in all areas and a risk of IV after the listed prevention and mitigation hazards.

IV-3.2.6 Kinetic Energy

Kinetic energy hazards present in this segment are described below.

IV-3.2.6.1 Power Tools

Experiment installation and support at FTBF, MC7, and M03 requires the use of a tech shop and power hand tools. Tech shop power tools are used only by trained personnel authorized by a tech shop Point of Contact. Such training and other tech shop safety requirements followed can be found in FESHM 7090: Tech Shop Safety. Power hand tools – typically battery-operated drills – can be used by experimenters although they are encouraged to coordinate with technicians for such activities. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.6.2 Pumps and Motors

A variety of pumps or motors may support SY120 experiments. There is a vacuum pump for Cerenkov detectors at FTBF. A compressed air system has a motor with an enclosed cage running the compressor. Motors of a variety of sizes move motion tables. Motors are all of the enclosed type with only exposed moving parts being whatever is attached to output shafts. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to III. No unique controls are in use.

IV-3.2.6.3 Motion Tables

FTBF has a variety of motion tables typically using stepper motors running jack screws to move translation platforms both horizontally and vertically. There is also a motion table in the M03 high rate tracking area. The tables move very slowly (less than an inch in ten seconds) but some tables are capable of moving/lifting up to 1500 lbs so there is a potential severe crushing hazard on the larger tables. Tables are equipped with both electrical and mechanical limit switches and the large high-capacity tables have an emergency crash button within reach of the table. Experimenters may also use very small tables capable of lifting only a few pounds and these may not have emergency crash buttons. Electronic controls such as a computer screen graphical user interface (GUI) and located near the high-capacity tables.

FTBF has two movable steel blocks within a larger steel pile located at the downstream end of the MT6 Section 1 enclosure. Lowering the blocks gives experimenters the ability to have a broadband muon beam in the MT6 Section 2 area. The blocks are controlled separately, and each is raised by a pneumatic cylinder above the block. Loss of compressed air to the pneumatic cylinder would cause the corresponding block to lower quickly. When the blocks are raised or lowered, there are pinch points in the mechanics at the top of the steel pile which can only be reached via a step ladder. Therefore, this hazard is guarded by location, being inaccessible during normal operations. The steel blocks drop into a beam channel in the steel absorber pile. The ends of the channel are designed to prevent an arm reaching into danger zone of moving block. Since the cylinders are remotely controlled, there are hazards working on or around the mechanics at the top of the absorber pile. Warning labels are placed on each assembly.

Risk Tables 22.16 – 22.18 show an unmitigated risk of I for this hazard and a residual risk of IV after the listed prevention and mitigation hazards.

IV-3.2.6.4 Mobile Shielding

N/A.

IV-3.2.7 Potential Energy

MTest/MCenter/M03 have hazards associated with potential energy. These hazards are described below.

IV-3.2.7.1 Crane Operations

MTest has a rail mounted overhead crane which has potential for physical injury from falling/crushing. The cranes are subjected to prescribed inspections and only trained operators are allowed to use the cranes. Barriers and access restrictions will be used as identified in any task specific HA. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.7.2 Compressed Gasses

MTest/MCenter/M03 gas bottles may be used for various facility and experimental purposes (ex: argon, nitrogen, CO2, r134a, SF6, krypton, isobutane, etc.) which can release potential energy. The TSW and ORC process identifies gases being brought by an experiment to assure cylinders are properly secured and use appropriate piping. There is training anyone working with gas cylinders takes. Compressed gases can pose a flammability or ODH risk. These risks are discussed in other sections of the SAD. The spaces covered in this segment are ODH 0 in MTest and MCenter and ODH 1 in the M03 high rate tracking area. New experiment gas needs are assessed through the engineering note process to ensure they comply with the current ODH postings. Risk matrix Tables 22.19-22.21 show an unmitigated risk of I and a residual risk of IV after the listed prevention and mitigation actions.

IV-3.2.7.3 Vacuum/Pressure Vessels/Pipes

The Cherenkov detector located in the front of MTest can be run with absolute pressures ranging from a rough vacuum to 21 psia. There are no permanent vacuum/pressure vessels in MCenter or M03. Experiments may bring these systems in for temporary use. The TSW and ORC system will flag any potential vessels for engineering notes and review prior to operation. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.7.4 Vacuum Pumps

A vacuum pump is present in MTest for use with the Cherenkov detector. Vacuum pumps may be brought in for experimental uses. MTest has pump in service to a Cherenkov detector. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to III. No unique controls are in use.

IV-3.2.7.5 Material Handling

Experiments may need forklifts, hand trucks, carts and other rigging for installation purposes that present a falling/crushing hazard. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.8 Magnetic Fields

There are permanent and electromagnets present in the Meson and Neutrino Switchyard 120 experimental areas which can have fringe fields present. These fields can present hazards both from flying objects and to medical implants.

IV-3.2.8.1 Fringe Fields

There is potential for experiments to bring permanent magnets with them for temporary use. This request is identified through the TSW and ORC process and fields are measured and labeled by industrial hygiene personnel according to FESHM.

There are two electromagnets present MC7, the MC7AN analyzer magnet in MC7 Section 1 and the Jolly Green Giant (JGG) magnet in MC7 Section 2. The MC7AN magnet has negligible fringe field. These are labeled and operated in accordance with FESHM.

All electromagnets discussed above have warning lights that flash when the magnet power supply is on and the magnet has the potential to be energized. There is facility-specific hazard awareness training connected to keyed entry to these spaces which further describes the hazard. All fields have been measured by the industrial hygiene group and posted accordingly. Magnets used for experiments go through the ORC process to ensure the standard operating procedure (SOP) and intended pattern of use of the magnet conforms with FESHM. Risk matrix Tables 22.22-22.24 show an unmitigated risk of I and a risk of IV after the listed prevention and mitigation actions.

IV-3.2.9 Other Hazards

Other categories of hazard are discussed and assessed below.

IV-3.2.9.1 Confined Spaces

There are no permanent confined spaces in MTest, MCenter, or M03. A tank or vessel may be brought by experiment with restricted access and is not intended for continuous occupancy. The TSW and ORC system will flag this vessel for appropriate SME review. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Assessment. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from III to IV. No unique controls are in use.

IV-3.2.9.2 Noise

N/A.

IV-3.2.9.3 Silica

Work with silica in this segment typically comes if the form of drilling into concrete to anchor equipment. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Assessment. When present, work involving this hazard implements the controls specified in the common Risk Matrix table which reduces the unmitigated risk from I to IV. No unique controls are in use.

IV-3.2.9.4 Ergonomics

Work in this segment takes place in both an office and industrial setting where repetitive motion and lifting injuries are possible. Work in the Meson and Neutrino Switchyard 120 experimental areas involving this hazard implements the controls specified in the common Risk Matrix table which bring the unmitigated risk level of I to IV. No unique controls are in use.

IV-3.2.9.5 Asbestos

N/A.

IV-3.2.9.6 Working at Heights

Work at heights in this segment typically involves the use of ladders for installing cables and detector equipment. Work in the Meson Switchyard 120 experimental areas involving this hazard implements the controls specified in the common Risk Matrix table which bring the unmitigated risk level of I to IV. No unique controls are in use.

IV-3.2.10 Access & Egress

In the event of hazardous events such as fire, ODH alarms, tornados, flooding, etc., access and egress paths are maintained to get personnel to safety.

IV-3.2.10.1 Life Safety Egress

MT6 Section 1 and 2 each have an egress point on both the east and west side of the enclosures. MC7 Section 1 and 2 have multiple exit doors into the surrounding yard which has one entrance back into the FTBF building. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in the Meson Switchyard 120 experimental areas involving this hazard implements the controls specified in the common Risk Matrix table which bring the unmitigated risk level of I to IV. No unique controls are in use.

IV-3.2.11 Environmental

Environmental hazards are addressed through compliance with legal and regulatory requirements imposed by DOE Orders, Federal/State/local regulations, and FESHM 8000 series chapters. Numerous activities at Fermilab have the potential to produce environmental impacts. These include air emission sources such as fuel combustion, greenhouse gases, component cleaning, paint spray booths, soil erosion from construction activities, oil spills from transformers and generators utilized within the electrical distribution system, and glycol spills from various cooling systems. The laboratory has an IEPA-approved air emissions permit and a Spill Prevention, Control and Countermeasures Plan (SPCC) that has been certified by a registered Professional Engineer. New activities are reviewed for potential environmental and regulatory issues as part of the National Environmental Policy Act (NEPA) process. The Meson Switchyard 120 experimental areas adhere to the laboratory regulatory standards and programs.

IV-3.2.11.1 Hazard to Air

Experimental groups may bring materials, chemicals or equipment which present a hazard to the air if released. One example being freon gas which is sometimes used in detector applications. These hazards are identified through the TSW and ORC process and evaluated by

SMEs prior to use with appropriate mitigations put in place. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in the Meson Switchyard 120 experimental areas involving this hazard implements the controls specified in the common Risk Matrix table. Both the unmitigated and mitigated risk level is IV. No unique controls are in use.

IV-3.2.11.2 Hazard to Water

Experimental groups may bring materials, chemicals or equipment which present a hazard to the water if released or spilled. One example being scintillator oil used in some experiments. These hazards are identified through the TSW and ORC process and evaluated by SMEs prior to use with appropriate mitigations put in place. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in the Meson Switchyard 120 experimental areas involving this hazard implements the controls specified in the common Risk Matrix table which bring the unmitigated risk level of I to IV. No unique controls are in use.

IV-3.2.11.3 Hazard to Soil

Experimental groups may bring materials, chemicals or equipment which present a hazard to the soil if released or spilled. One example being scintillator oil used in some experiments. These hazards are identified through the TSW and ORC process and evaluated by SMEs prior to use with appropriate mitigations put in place. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in the Meson 120 experimental areas involving this hazard implements the controls specified in the common Risk Matrix table which bring the unmitigated risk level of I to IV. No unique controls are in use.

IV-3.3. Summary of Hazards to Members of the Public

The Meson Switchyard 120 experiments in the Meson beamline enclosures presents no specific hazards to members of the public.

IV-3.4. Summary of Credited Controls

As described in Chapters 1-10 of the Fermilab SAD, credited controls are designed to reduce the risk of accelerator operations hazards to an acceptable level. Although the experiments are installed in the Meson beamline areas, the experiments themselves do not affect the Maximum Credible Incident (MCI) as presented in Section III Chapter 13 for the Meson Area beamlines. The MCI for the experimental area is covered by the MCI analysis for the beamlines which pass through the experimental enclosures. The Meson area experiments do not require any additional credited controls.

New experiments for the Meson Switchyard 120 Experimental Areas are proposed through a Technical Scope of Work (TSW). If an experiment introduces new hazards or requires changes to beamline configuration or operations the USI screening process would evaluate any necessary changes to shielding assessments, the SAD chapter, or ASE for III-13 or IV-03.

IV-3.5. Defense-in-Depth Controls

IV-3.5.1 Administrative Controls

Administrative controls and procedures have been put in place to ensure safe operations at the Meson Switchyard 120 experimental areas. Operational readiness of each experiment is governed by PPD ESH 006 ES&H Review of Experiments. Subject matter experts review each aspect of the experiment prior to operations to ensure safe operations. The review includes procedure, hazard analysis and document reviews and walk-throughs of the experiment components. Division head(s) of the area(s) in which that experimental components reside grant approval for operations.

IV-3.5.1.1 Operation Authorization Document

Commissioning, normal operations, and emergency management of the Meson SY 120 experimental areas are all conducted under the auspices of the Particle Physics Directorate Headquarters and the Environment, Safety & Heath Division.

IV-3.6. Decommissioning

DOE Field Element Manager approval shall be obtained prior to the start of any decommissioning activities for the Meson and Neutrino Switchyard 120 Experimental Areas.

IV-3.7. Summary and Conclusion

This chapter of the Fermilab Safety Assessment Document identifies and assesses specific radiological and other hazards associated with commissioning and operation of the Fermilab Meson Switchyard 120 Experimental Areas. The chapter identifies and describes designs, controls, and procedures to mitigate Fermilab Meson Switchyard 120 Experimental Areas' hazards. In addition to the specific safety considerations presented in this chapter, Fermilab Meson Switchyard 120 Experimental Areas are subject to the global and more general safety requirements, controls and procedures outlined in Section 1 of this Fermilab Safety Assessment Document.

The Fermilab Meson and Neutrino Switchyard 120 Experimental Areas have been constructed, commissioned and will be operated within the specific and general considerations of this safety assessment. The preceding discussion of the hazards presented by the Fermilab Meson Switchyard 120 Experimental Areas' operations and the credited controls established to mitigate those hazards demonstrate that the experiments can be operated in a manner that will produce minimal hazards to the health and safety of Fermilab workers, researchers, members of the public, as well as to the environment.

IV-3.8. References

[1] Fermilab Radiological Control Manual

[2] Fermilab Environment, Safety and Health Manual Chapter 2005 (FESHM 2005), *Operational Readiness Clearance.*

[3] Fermilab Environment, Safety and Health Manual Chapter 2010 (FESHM 2010), Planning and Review of Accelerator Facilities and Their Operations

[4] 2003 Shielding Assessment for the Switchyard 120 Project, C. Brown, T. Kobilarcik, G. Koizumi, E. Ramberg, W. Higgins, April 8, 2003

[5] Addendum to the SY 120 Shielding Assessment for Continued Operation of the Meson Center Beam Line, T. Kobilarcik, W. Schmitt, November 25, 2013

[6] LArIAT Tertiary Beamline Post-Assessment Memo

[7] MC7 NOvA Tertiary Beamline Post-Assessment Memo

[8] TOAD MC7 post assessment 031323

[9] Post Assessment 04-28-16 Operation at -32 GeV

[10] Fermilab Environmental Safety and Health Manual – All references to FESHM can be found here at the current web link: http://esh.fnal.gov/xms/ESHQ-Manuals/FESHM

IV-3.9. Appendix – Risk Matrices

Risk Assessment methodology was developed based on the methodology described in DOE-HDBK-1163-2020. Hazards and their potential events are evaluated for likelihood and potential consequence assuming no controls in place, which results in a baseline risk. A baseline risk (i.e., an unmitigated risk) value of III and IV does not require further controls based on the Handbook. Events with a baseline risk value of I or II do require prevention and/or mitigation measures to be established in order to reduce the risk value to an acceptable level of III or IV. Generally, preventive controls are applied prior to a loss event, reflecting a likelihood reduction, and mitigative controls are applied after a loss event, reflecting a consequence reduction. For each control put in place, likelihood or consequence can have a single "bin drop", resulting in a new residual risk (i.e., a mitigated risk). This risk assessment process is repeated for each hazard for Facility Workers (FW), Co-Located Workers (CLW), and Maximally-Exposed Offsite Individual (MOI). At the conclusion of the risk assessments, controls that are in place for the identified accelerator specific hazards are identified as Credited Controls and further summarized in Section 0 of this Chapter as well as SAD Chapter VII-A.1 *Accelerator Safety Envelope – Fermi Main Accelerator.*