FERMI NATIONAL ACCELERATOR LABORATORY

ACCELERATOR SAFETY ENVELOPE

Fermilab Main Accelerator

Revision 13 November 20, 2023

Appendix A of the Safety Assessment Document

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Accelerator Safety Envelope

Fermilab Main Accelerator

Approval Page

Line Organization Review and Recommendation

This Appendix A Chapter 01 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD), *Accelerator Safety Envelope – Fermilab Main Accelerator*, was prepared and reviewed by the staff of the Environment, Safety & Health Division (ESH) Accelerator Safety Department in conjunction with the Accelerator Directorate (AD) Line Management for each segment of the Fermilab Main Accelerator.

Signatures below indicate review of this Accelerator Safety Envelope (ASE), and recommendations that it be incorporated into the Appendices of the Fermilab SAD.

☐ _____
AD Associate Lab Director

☐ _____
Accelerator Safety Department Head

☐ _____
SAD Review Subcommittee Chair

Directorate & Fermi Site Office Final Approval

Final approval of this Accelerator Safety Envelope for the Fermilab Main Accelerator is granted by the Fermilab Director and the DOE Field Element Manager.

_____
Director, Fermi National Accelerator Laboratory

_____
DOE Field Element Manager, Fermi Site Office

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Revision History

Author	Rev. No.	Date	Description of Change
Maddie Schoell	13	November 20, 2023	Following the revision of Department of Energy (DOE) Order 420.2C, *Safety of Accelerators*, to DOE O 420.2D and the FY23 PEMP Notable Goal 4, including comments and concerns noted in the memo "Request to Approve Fermilab's Accelerator Safety Envelope and Concurrence with Safety Assessment Documents for the Neutrino, Meson and Neutrino Switchyard 120 Experimental Areas Including SpinQuest" dated January 4, 2023 – major revisions were made to the ASE. • Separated ASEs for the Fermilab Main Accelerator from the FAST Accelerator, removing FAST from this ASE. • Major overhaul of outline of ASE, including general descriptions and information within Section 1 through Section 6 • Added 0 to specifically describe Credited Controls for each segment of the Fermilab Main Accelerator • Updated shielding assessment reference for the Neutrino Area. • Removed reference for Memo, "Accelerator Safety Envelope Limitations for Operating Areas" and included content from the memo within the ASE. Based on the "Phased Review Approach to Ensure Readiness to Operate Under DOE O 420.2D", select segments of the Fermilab Main Accelerator will be reviewed over the course of eight (8) reviews. Only applicable segments will be included in the current revision of the ASE. • IRR #1a applicable Segments: ○ Linac ○ 400 MeV Test Area (MTA)

Author	Rev. No.	Date	Description of Change
Maddie Schoell	12	August 25, 2020	Updated "Area" column for MuCool Test Area to reflect new name, MeV Test Area (MTA). Updated shielding assessment references for MeV Test Area. Updated safety envelope beam intensities for MeV Test Area, and updated associated reference. Updated "ASE Violation Determination and Actions" section to clarify deficiency in credited control and ASE violations.
Maddie Schoell	11	February 11, 2020	Updated shielding assessment references for the Muon Campus. Safety envelope beam intensities did not change. Updated "Area" column titles for Muon Campus areas for clarity.
John E. Anderson Jr.	10	November 12, 2019	Updated text for the "Control" section of the Operator Staffing section to reflect MCR responsibility for accelerator operations within the ASE beam intensity limits. Updated organizational name changes.
John E. Anderson Jr.	9	January 11, 2018	Removed Experimental ORC requirement from the ASE. Updated reference to the Routine Monitoring Program to reflect ESH Centralization. Clarified when shielding deficiencies would be an ASE violation.
John E. Anderson Jr.	8	August 28, 2017	Updated ASE energy limit for the Fermilab Accelerator Science and Technology (FAST) Facility.
John E. Anderson Jr.	7	March 3, 2017	Updated titles from ES&H reorganization, updated PPD ORC process to the FESHM ORC Process, and updated shielding assessment references for the Muon Campus and Booster accelerator areas. Safety envelope beam intensities did not change. Added Muon Campus 8 GeV beam on target intensity scaled from the 120 GeV intensity for clarity.
John E. Anderson Jr.	6	January 2, 2015	Added Safety Envelope beam intensity limits for the Advanced Superconducting Test Accelerator (ASTA) Injector. Changed Antiproton Source to Muon Campus. Updated references.

Author	Rev. No.	Date	Description of Change
John E. Anderson Jr.	5	January 3, 2014	Updated ASE text to reflect recommendations from the Accelerator Readiness Review conducted October 1-3, 2013. Changes included moving numerical beam operating intensity limits from the ASE to a Division level document, scaling numerical beam safety envelope intensity limits to a 500 mrem accident condition, removing operating surveillance limits, and removing industrial hazards such as oxygen monitoring, cryogenic relief valve monitoring, and flammable gas system monitoring.
John E. Anderson Jr.	4	April 25, 2013	Updated Department of Energy (DOE) DOE Order 420.2B, *Safety of Accelerator Facilities*, to DOE O 420.2C. Updated ASE text to reflect credible accident scenarios. Modified Operating and Safety Envelope beam parameters for the Main Injector, Recycler, and NuMI. Updated shielding assessment references for the revised Main Injector, Recycler, and NuMI shielding assessments. Updated Linac groundwater limit reference to new MARS calculations. Removed Operating and Safety Envelope beam parameters for Tevatron Circulating Beam, A0 and C0 Abort Absorbers, and the Pelletron; placing the areas in standby. Removed the Booster Radiation Damage Facility Operating and Safety Envelope beam parameters.
John E. Anderson Jr.	3	February 15, 2012	Added Operating and Safety Envelope beam intensity limits for the Neutrino Area.
John E. Anderson Jr.	2	March 21, 2011	Added Operating and Safety Envelope beam intensity limits for the HINS Linac at MDB.
John E. Anderson Jr.	1	January 20, 2011	Added Operating and Safety Envelope beam intensity limits for the MuCool Test Area.

Author	Rev. No.	Date	Description of Change
John E. Anderson Jr.	0	December 10, 2009	Initial release of the laboratory-wide Accelerator Safety Envelope (ASE). The ASE is derived from the Safety Class Structures, Systems, or Components section of Fermilab Environment Safety and Health Manual (FESHM) Chapter 3010, *Significant and Reportable Occurrences*, and the Safety Envelope section of the existing Fermilab Safety Assessment Documents (SADs). This document supersedes and replaces the Safety Envelope section of the existing Fermilab SADs. Completed Safety Envelope calculations for the 8 GeV Line and MiniBooNE areas and revised Safety Envelope. Revised 8 GeV Line and MiniBooNE Operating limits to support future program needs based on post assessment documents.

Section 1. Introduction and Scope

This document constitutes the integrated Accelerator Safety Envelope (ASE) for full power operation of all segments of the Fermilab Main Accelerator. It defines the Credited Controls that are established for all of the segments that make up the Fermilab Main Accelerator to assure that the level of risk to all workers, the public, and the environment is maintained at acceptable levels. This ASE is established in accordance with the DOE Order 420.2D, *Safety of Accelerators*, (DOE O 420.2D), and as flowed down through the Fermilab Environment, Safety and Health Manual (FESHM) including the Fermilab Radiological Control Manual (FRCM).

Section 2. Select Definitions and Acronyms

The following terms and/or acronyms are commonly used when discussing operation of the Fermilab Main Accelerator. Definitions that come directly from DOE O 420.2D, *Safety of Accelerators*, are noted with an asterisk (*), with further information on the interpretation and application of the definition for use at the Fermilab Main Accelerator in italics.

***Accelerator** A device and its components employing electrostatic or electromagnetic fields to impart kinetic energy to molecular, atomic, or sub-atomic particles and capable of creating a radiological area as defined by 10 CFR Part 835, Occupational Radiation Protection. Accelerator components include injectors, targets, beam dumps, detectors, experimental enclosures, accelerator enclosures, experimental areas, and experimental apparatus utilizing the accelerator. The accelerator also includes associated support and test facilities, equipment, systems, and utilities necessary to operate the accelerator or utilize the accelerated beam.

***Accelerator Facility** The accelerator, plant, buildings, structures, and equipment supporting the accelerator and its operations that are under direct control of the contractor

All facilities at Fermilab in some way contain components or conduct activities supporting an accelerator and its operations. As such, all facilities are described in the Safety Assessment Document (SAD).

***Accelerator Operations** Activities within the accelerator facility that, over the lifecycle of the facility, support 1) production or utilization of accelerator beams; 2) research and experimental activities utilizing accelerator beams; 3) handling, storage and analysis of accelerator induced radioactive components and materials within the accelerator facility boundary; 4) receipt, preparation, assembly, inspection, and installation of samples into the accelerator beam; or 5) removal, disassembly, handling, analysis, and storage for radioactive dose minimization to meet the definition of ALARA in 10 CFR Part 835, Occupational Radiation Protection, or transportation requirements, and packaging of samples after use in the

accelerator beam. Accelerator Operations excludes radioisotope processing activities that are not required to operate or maintain the accelerator.

***Accelerator Readiness Review (ARR)** A structured method for verifying that hardware, personnel, and procedures associated with commissioning or routine operations are ready to permit the activity to be undertaken safely.

***Accelerator Safety Envelope (ASE)** A documented set of verifiable physical and administrative requirements, bounding conditions, and credited controls that ensure safe operation and address accelerator specific hazards and risks.

Accelerator Safety Envelope Intensity Calculated intensity that, assuming a one (1) hour point source loss would produce a 500 mrem accident condition

Accelerator Specific Hazard Hazards are classified as Accelerator Specific when their nature is uniquely defined by the configuration of the accelerator and they are not fully mitigated by Fermilab standard safety management programs. The passive, active engineered, and administrative mitigations which reduce accelerator specific hazards within Applicable Accelerator Facilities from unacceptable to acceptable risk are the Credited Controls

Applicable Accelerator Facility An Accelerator Facility further posted as an Exclusion Area.

***Commissioning** A phase of an accelerator facility operation that is typically used to conduct initial beam testing and/or verify design specifications. Commissioning periods may be tailored to the needs of each facility and there may be great variations in their duration, breadth, and formality, but in all cases, the activities will be bounded by an ASE and preceded by an ARR and DOE approval.

***Credited Control** Controls determined through the Safety Analysis to be essential for safe operation directly related to the protection of workers, the public, and the environment.

Credited Controls are implemented to mitigate Accelerator Specific Hazards within Applicable Accelerator Facilities to acceptable levels. For other facilities, controls to mitigate similar hazards are managed through programs and requirements specified in FESHM.

***DOE Element** First-tier organizations at DOE/NNSA HQ and in the field as listed in the Correspondence Style Guide, Office of the Executive Secretariat.

***DOE Field Element Manager** The manager having overall responsibility for a DOE field element including execution of oversight policy implementation. The Field Element Manager directs activities of DOE/NNSA field or site offices and has line accountability for all site program, project execution, and contract management.

The Fermilab Site Office (FSO) Manager is the DOE Field Element Manager.

***DOE Program Secretarial Officer (PSO)** An Assistant Secretary, Office Director, Head of Program Element, or NNSA Deputy Administrator to whom designated field offices directly report and who has overall landlord responsibilities for the assigned direct reporting elements.

Nominal Operating Intensity Intensity identified by the machine and/or Project, supported by the Shielding Assessment.

Maximum Operating Intensity The maximum intensity a given segment is allowed to operate at without requiring additional actions/approvals/responses. This value is the Nominal Operating Intensity plus 5%, in order to accommodate potential fluctuation in beam intensity due to changes in efficiency.

***Radiation** Ionizing radiation, including the accelerated particle beam and the radiation produced when the beam interacts with matter or changes direction. Radiation includes alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions.

***Radioisotope Processing** Chemical, thermal, or physical actions taken to separate, isolate, refine, or enrich specific isotopes of a chemical element.

***Residual Radioactivity** Radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from the accelerator or accelerator operations.

***Reviewed Safety Issue** The outcome of the evaluation and determination phase of the USI Process.

***Risk** A quantitative or qualitative expression of possible harm, which considers both the probability that a hazard will cause harm and the amount of harm; or, alternatively, an estimate of the probability of occurrence of a hazard-related incident and the severity of the consequence associated with the incident.

Fermilab utilizes a qualitative risk assessment, following the methodology found in DOE-HDBK-1163-2020, Integration of Hazard Analyses.

***Safety Analysis** A documented process to systematically identify the hazards of a given operation; including a description and analyses of the adequacy of measures taken to eliminate, control, or mitigate the hazards and risks of normal operation; and identification and analyses of potential accidents and their associated risks.

***Safety Assessment Document (SAD)** A document containing the results of a Safety Analysis for an accelerator or accelerator facility pertinent to understanding the risks to workers, the public, and the environment of operating the accelerator.

***Unreviewed Safety Issue (USI)** An activity or discovered condition with accelerator specific hazards that have yet to be evaluated to determine if the activity or discovered condition introduces accelerator specific hazards that are not adequately addressed by the current SAD and approved ASE.

***USI Process** The process or methodology used to evaluate/review USIs to determine if the activity or discovered condition is adequately addressed by the current SAD and approved ASE.

Section 3. Description of Credited Controls

The Credited Controls identified in the ASE are a set of passive, active engineered, and administrative controls in use at the Fermilab Main Accelerator that define the bounding conditions and limitations for safe and environmentally sound operations. In accordance with FRCM Article 236, Fermilab utilizes Credited Passive and Active Engineered Controls whenever the maximum credible incident condition can exceed limits specified in Table 1.

Table 1. Acceptable Dose Levels Used in MCI Analysis.

Dose	Location	Potentially Exposed Individual
5 R	Inside service buildings	Facility Worker and/or Co-Located Worker
500 mrem	Outside of enclosure/facility and surrounding shielding, in non-publicly accessible areas	Facility Worker and/or Co-Located Worker
100 mrem	Outside of enclosure, in location where the public is invited	Maximally-exposed Off-Site Individual (a.k.a., a member of the public)

The Credited Controls listed in the ASE must be in place and functional for all operational areas. During periods of down time or maintenance, Credited Controls may be removed and managed under the Safety Configuration Management program to ensure they are replaced prior to resumption of operations.

For each Credited Control, the following is specified:

- **Applicability** – the condition in which the Credited Control is valid.
- **Basis** – description of the need for the Credited Control.
- **Credited Control** – specific elements that must be in place during beam operation. Beam operation to the affected area without required elements in place is an ASE violation.
- **Required Surveillance** – management and monitoring practices that must be performed to assure continued effectiveness of the Credited Control. Surveillances are to be carried out at the minimum specified interval. Beam operation to the affected area without the required surveillance being performed within the minimum specified interval is an ASE violation.
- **Response** – actions to be taken if there is a suspected deficiency, missing control, or other potential ASE violation for that particular Credited Control.

The Credited Controls are divided into three main categories: passive controls, active engineered controls, and administrative controls.

Passive

Passive Credited Controls are elements that are part of the physical design of the facility that require no action to function properly. These are fixed elements that take human intervention to remove. The types of Passive Credited Controls in use for the Fermilab Main Accelerator include:

- Shielding (i.e., Permanent/Structural, Labyrinths, Movable, Penetration Shielding)

Acceptable methods for configuration of movable and/or penetration shielding include, but are not limited to: locked chains, Unistrut to block or inhibit movement, cover plates over penetration holes, etc.

Active Engineered

Active Engineered Credited Controls are systems designed to reduce the risks from accelerator operations to an acceptable level. The types of Active Engineered Credited Controls in use for the Fermilab Main Accelerator include:

- Radiation Safety Interlock System (RSIS)
- Oxygen Deficiency Hazard (ODH) Safety System

Radiation Safety Interlock System (RSIS)

Radiation Safety Interlock Systems (RSIS) are used to prevent injury, death, or serious over-exposure from beam-on radiation. The principle method employed by the RSIS is to establish and maintain Exclusion Areas surrounding accelerator operating areas. If there is a potential for personnel to inadvertently access the defined Exclusion Area, the RSIS is designed to inhibit accelerator operations in that area.

The RSIS may also include interlocked radiation monitors to supplement passive shielding Credited Controls. Specific radiation monitors are designated as Credited Controls in areas where passive

shielding is insufficient to limit potential exposure in the maximum credible incident to less than limits specified in Table 1. If dose rates exceed specified levels, the RSIS is designed to inhibit accelerator operations in that area.

The RSIS utilize a modular redundant design where no single component failure will result in a loss of protection. To accomplish this, two separate fail-safe circuits are used to detect specific conditions. All circuits within the RSIS are designed in such a way that if a circuit fails, or specified input is lost, the failure would initiate a system shutdown resulting in a safe condition.

Oxygen Deficiency Hazard (ODH) Safety Systems

ODH Safety Systems are used to prevent injury or death from exposure to oxygen deficient environments. ODH Classifications are determined based on a quantitative risk assessment, further described in FESHM 4240. ODH Classifications are then used to determine required personnel training and qualification and other ODH control measures. ODH Safety Systems utilize various components (e.g., area oxygen monitors, vents, fan, etc.) to maintain the posted ODH Classification.

ODH Safety System component failures are taken into account in the initial ODH analysis, and surveillance requirements are determined based on the analysis. In the event of a known failure of an ODH Safety System component that is necessary to maintain the original ODH Classification, the area is evacuated and ODH Classification is updated as needed based on existing out-of-service policy or updated ODH analysis.

ODH Safety System components that are required to maintain the posted ODH Classification within an interlocked and/or posted Exclusion Areas will be identified as Credited Controls and summarized in this ASE.

Administrative

Administrative Credited Controls encompass the human interactions that define safe operations. These are the accelerator operating policies and procedures that are followed to ensure safe accelerator operations. The types of Administrative Credited Controls in use for the Fermilab Main Accelerator include:

- Operation Authorization Document
    - Must include the following information:
        - Segment Name
        - Issue Date
        - Mode(s) of Operation
        - Operating Parameters (i.e., ASE Intensity Limit)
        - Critical Device Controller (CDC)
        - Critical Devices
        - Exclusion Area(s)
        - Credited Controls

i. Shielding Requirements
ii. RSIS Required Components and Inputs, including interlocked detectors
iii. ODH System Requirements
iv. Staffing Requirements
v. Search & Secure Program Requirements
vi. Accelerator Operating Parameter

- May also include additional information beneficial to those operating the Fermilab Main Accelerator

- Staffing
- Search & Secure
- Accelerator Operating Parameter (i.e., ASE Intensity)

ASE Intensity Determination

The ASE Intensity Limit is determined as follows –

> The maximum credible intensity limit is determined based on how much beam can be produced and transported given design parameters and limitations of the accelerator or beamline and of upstream accelerators and beamlines. The maximum credible incident (MCI) is then determined as the worst case accident scenario where beam of the maximum credible intensity is not transported cleanly and may result in more than 500 mrem in an hour to the public or 5 rem in an hour to a worker.

Section 4. ASE Violation Determination and Actions

Determination

Any beam operation to the affected segment of the Fermilab Main Accelerator with a known loss of Credited Control (except ODH Safety System Credited Controls) and/or the safety function of the Credited Control is a violation of the ASE.

> For Credited Controls that have additional overburden or Defense-in-Depth controls, it may not be immediately obvious if a deficiency is in the overburden or in the Credited Controls. In this case, it is not yet known if there even is a deficiency in Credited Controls constituting an ASE Violation. In these circumstances, the appropriate Line Organization and ESH Division Subject Matter Experts (SMEs) will investigate to determine if Credited Controls were impacted. This determination shall be documented following the USI Process, as described in Section 6 of this ASE. If it is determined that Credited Controls were impacted, beam operations shall be terminated immediately and not resume until the Reviewed Safety Issue (RSI) is finalized. If beam operations were to resume without the Reviewed Safety Issue (RSI) being finalized, that would constitute an ASE Violation.

For ODH Safety System Credited Controls, in the event of a known failure of an ODH Safety System component that is necessary to maintain the original ODH Classification, and the Cryo Coordinator/Facility Manager determine that there is a need to reclassify the area (as opposed to

replacing components), the area is evacuated and ODH Classification is updated as needed based on existing out-of-service policy or updated ODH analysis. Reentry into the area, before the ODH Classification is updated, is limited to personnel approved by the Cryo Coordinator/Facility Manager to perform work necessary for the ODH reclassification, any other access is a violation of the ASE.

Beam operation of the segment of the Fermilab Main Accelerator beyond the specified ASE Intensity Limit is a violation of the ASE.

Beam operation of the segment of the Fermilab Main Accelerator with required surveillance of a Credited Control not conducted within specified frequency, as defined for each segment in 0 of this ASE, is an ASE violation.

Questions regarding determination of an ASE violation shall be addressed to the Environment, Safety & Health (ESH) Division Accelerator Safety Department Head and the Accelerator Division (AD) Associate Lab Director.

Actions

In the event that the ASE is violated, beam operations to the affected segment of the Fermilab Main Accelerator shall be terminated and put in a safe and stable configuration, and not resume until the circumstances of the event are reviewed and approval to resume operations is received. Non-affected segments of the Fermilab Main Accelerator may continue operations. The USI Process, as described in Section 6 of this ASE, will be used to analyze and document the circumstances of the ASE violation. Once the RSI has been finalized for the event causing the ASE violation, approval to resume operations to the affected segment of the Fermilab Main Accelerator will be issued by the AD Associate Lab Director and the DOE Field Element Manager.

Events determined to be ASE violations follow FESHM Chapter 3010 *Significant and Reportable Occurrences*, to provide the appropriate DOE notification and reporting.

Section 5. Configuration Management for Credited Controls

To ensure the integrity of the Credited Controls during accelerator operation, several methods of Configuration Management are in place.

- Excavation within the “Excavation Waiver Prohibited Zone” around the accelerator are required to go through the JULIE process. Part of the JULIE process includes ES&H Division Radiation Safety personnel review to determine if required shielding may be impacted.
- Required movable and penetration shielding is posted and/or locked and/or bolted in place where applicable.
- Components that are part of the Radiation Safety Interlock System (RSIS) are labeled.
- Surveillance is performed, as specified in 0.

If shielding is planned to be removed, the assigned Radiation Safety Officer (RSO) is responsible for ensuring the affected segment of the Fermilab Main Accelerator is locked off in a safe state, using RSO Configuration Control locks.

If any Credited Control is not in place, either planned or discovered, the assigned RSO is responsible for ensuring the affected segment of the Fermilab Main Accelerator is locked off in a safe state, using RSO Configuration Control locks.

Removal of Credited Controls (i.e., rescinding Operation Authorization Documents, removing shielding or fencing, etc.) during maintenance periods is common, and the assigned RSO is responsible for ensuring the affected segment of the Fermilab Main Accelerator is locked off in a safe state, using RSO Configuration Control locks.

The ES&H Division Radiation Physics Operations and Accelerator Safety Departments utilize a Configuration Control Log to track instances of placing affected segment of the Fermilab Main Accelerator in a Configuration Controlled off state. This Log keeps track of reasons why the affected segment of the Fermilab Main Accelerator was locked off, what must be done prior to resuming operations, and confirmation that conditions are back in place and confirmed before operations are permitted to resume.

Section 6. Unreviewed Safety Issue (USI) Process

The Unreviewed Safety Issue (USI) Process is used to evaluate proposed activities/modifications and/or discovered conditions to ensure all hazards are adequately addressed in by the current SAD and approved ASE. The USI Process utilizes a USI Screening Form to determine if the proposed activity and/or discovered condition warrant further evaluation, and a USI Evaluation Form to determine if the proposed activity and/or discovered condition is a USI and what actions need to be taken. For discovered conditions, if the USI Screening Process determines that further USI Evaluation is needed, affected accelerator operations shall be stopped until the conclusion of the USI Process. At the conclusion of the USI Process, the review of the proposed activity/modification and/or discovered condition is classified as a Reviewed Safety Issue (RSI).

Proposed activities/modifications and/or discovered conditions at the Fermilab Main Accelerator are subject to the USI Process.

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Section 7. Summary of Credited Controls for All Segments of the Fermilab Main Accelerator Complex

Linac Credited Controls

Passive – Shielding

Applicability	During beam operations to the Linac segment of the Fermilab Main Accelerator.
Basis	To reduce the accumulated dose from a Maximum Credible Incident (MCI) for a radiological hazard, as defined in Section III-1.3.1.1 of the Fermilab SAD.
Credited Control	The following forms of passive shielding: • 9.6 effective feet of dirt shielding between the interior surface of the enclosure walls and the surface of the berm. • The wall between the Linac enclosure and the Linac upper and lower gallery. • The concrete block wall separating the Linac enclosure and the ITA experimental hall. • Concrete shielding blocks that fill the utility and RF waveguide penetrations between the Linac enclosure and the lower Linac gallery. • Poly beads that fill the upper waveguide penetrations for the 400 MeV Linac upgrade.
Required Surveillance	Required shielding shall be verified annually, not to exceed twelve (12) months.
Response	Beam operation to the Linac will be terminated immediately once a USI Screening determines that a discovered condition warrants USI Evaluation. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Active Engineered – Radiation Safety Interlock System (RSIS)

Applicability	During beam operations to the Linac segment of the Fermilab Main Accelerator.
Basis	To mitigate the accumulated dose from a Maximum Credible Incident (MCI) for a radiological hazard, as defined in Section III-1.3.1.1 of the Fermilab SAD, to the following conditions: • Less than 500 mrem accumulated dose in an hour for a maximally-exposed offsite individual (MOI) in non-public areas of the campus. • Less than 100 mrem accumulated dose in an hour for a maximally-exposed offsite individual (MOI) in areas of the campus where the public is invited.

- Less than 5 rem accumulated dose in an hour for a facility worker or a co-located worker anywhere on campus.

To ensure protection against inadvertent access into the Linac enclosure during beam operations.

Credited Control

The Radiation Safety Interlock System (RSIS) must prevent entry into the following Exclusion Area(s) during appliable beam operation:

- Linac

Required components of the RSIS shall be specified in the Linac's Operation Authorization Document.

The following components of the Radiation Safety Interlock System (RSIS) shall be in place, with no known loss of safety function, during applicable beam operations.

Radiation Safety System – Interlocked Radiation Monitors

Table 2. Linac Radiation Monitors Credited Controls

Type	Location	Trip Setting (mrem/hr)
Chipmunk	Linac Dump #1 Berm US	50
Chipmunk	Linac Dump #1 Berm DS	50
Chipmunk	Linac Enclosure Tank #1	50
Chipmunk	Linac Gallery Tank #2	50
Chipmunk	Linac Gallery Tank #3	50
Chipmunk	Linac Gallery Tank #4	50
Chipmunk	Linac Gallery Tank #5	50
Chipmunk	Linac Gallery Tank #6	50
Chipmunk	Linac Gallery Tank #7	50
Chipmunk	Linac Gallery Tank #8	50
Chipmunk	Linac Gallery Tank #9	50
Scarecrow	Linac Enclosure 400 MeV Labyrinth	500
Scarecrow	Linac Enclosure Tank #3	4000
Chipmunk	Booster Chute	50
Chipmunk	Booster Tunnel Dump #1	50

Required Surveillance

Operation of all access control interlock components shall be functionally tested at an interval no greater than 15 months.

Area radiation monitors shall be maintained and calibrated on an interval no greater than 15 months.

Response

Beam operation to the Linac will be terminated immediately once a USI Screening determines that a discovered condition warrants USI Evaluation. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Operation Authorization Document

Applicability	During beam operations to the Linac segment of the Fermilab Main Accelerator.
Basis	To summarize the bounding conditions for safe operation of the Linac, and to provide explicit approval for operations of the Linac.
Credited Control	An approved Linac Beam Permit & Running Condition shall be issued prior to Linac beam operations.
Required Surveillance	The Linac Beam Permit and Running Condition shall be verified annually, not to exceed twelve (12) months.
Response	Beam operation to the Linac will be terminated. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Search and Secure

Applicability	Prior to beam operations to the Linac segment of the Fermilab Main Accelerator.
Basis	To ensure protection against inadvertent access into the Linac enclosure during beam operations
Credited Control	A valid Search & Secure shall be performed by the AD Operations Department.
Required Surveillance	None
Response	Beam operation to the Linac will be terminated immediately once a USI Screening determines that a discovered condition warrants USI Evaluation. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Staffing

Applicability	During beam operations to the Linac segment of the Fermilab Main Accelerator.
Basis	To ensure accelerator operations are disabled and initiate an immediate response in the event of a determined ASE violation.

Credited Control	The following staffing shall be in place during applicable beam operation: • At least one member of the AD Operations Department who has achieved the rank of Operator II or higher shall be on shift. • At least one member of the AD Operations Department shall be present in the Main Control Room (MCR).
Required Surveillance	none
Response	Beam operation to the Linac will be terminated. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Accelerator Operating Parameter

Applicability	During beam operations to the Linac segment of the Fermilab Main Accelerator.
Basis	To ensure operations within bounding conditions used in the MCI analysis.
Credited Control	The following intensity shall not be exceeded: 2.58e18 protons/hour
Required Surveillance	none
Response	Beam operation to the Linac will be terminated. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

400 MeV Test Area (MTA) Credited Controls

Passive – Shielding

Applicability	During beam operations to the MTA segment of the Fermilab Main Accelerator.
Basis	To reduce the accumulated dose from a Maximum Credible Incident (MCI) for a radiological hazard, as defined in Section III-2.3.1.1 of the Fermilab SAD.
Credited Control	The following forms of passive shielding: • 17.2 effective feet of dirt shielding between the interior surface of the enclosure walls and the surface of the berm. • Three (3) 3-inch gas manifold penetrations filled with poly beads • Voids in the 20-inch vent penetration filled with poly beads • Obsolete 10-inch cryo penetration filled with poly beads • Obsolete 8-inch cryo penetration filled with poly beads • Four (4) obsolete 4-inch cryo penetrations filled with poly beads • 201 MHz 9-inch coaxial transmission line through MTA/Linac shield wall filled with sandbags • 805 MHz 10x5 inch waveguide through MTA/Linac shield wall filled with sandbags • 18x18 inch cable tray to Linac gallery filled with sandbags • Berm penetration filled with sand and poly beads • Beam pipe penetration voids filled with sand
Required Surveillance	Required shielding shall be verified annually, not to exceed twelve (12) months.
Response	Beam operation to the MTA will be terminated. Beam operation to the MTA will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Active Engineered – Radiation Safety Interlock System (RSIS)

Applicability	During beam operations to the MTA segment of the Fermilab Main Accelerator.
Basis	To reduce the accumulated dose from a Maximum Credible Incident (MCI) for a radiological hazard, as defined in Section III-2.3.1.1 of the Fermilab SAD, to the following conditions: • Less than 500 mrem accumulated dose in an hour for a maximally-exposed offsite individual (MOI) in non-public areas of the campus.

- Less than 100 mrem accumulated dose in an hour for a maximally-exposed offsite individual (MOI) in areas of the campus where the public is invited.
- Less than 5 rem accumulated dose in an hour for a facility worker or co-located worker anywhere on campus.

To ensure protection against inadvertent access into the MTA enclosure during beam operations.

Credited Control

The Radiation Safety Interlock System (RSIS) must prevent entry into the following Exclusion Area(s) during appliable beam operation:

- MTA

Required components of the RSIS shall be specified in the MTA's Operation Authorization Document.

The following components of the Radiation Safety Interlock System (RSIS) shall be in place, with no known loss of safety function, during applicable beam operations.

Radiation Safety System – Interlocked Radiation Monitors

Table 3. MTA Radiation Monitors Credited Controls

Type	Location	Trip Setting (mrem/hr)
Chipmunk	Linac High Ceiling	50
Chipmunk	Linac Ramp – top of berm upstream	50
Chipmunk	Linac Ramp – top of berm downstream	50
Chipmunk	Beam Stop Alcove – top of berm upstream of hatch	50
Chipmunk	MTA Upstream Stub – above UVB11 (SQA)	50
Chipmunk	MTA Hall – Ceiling Vent	50
Chipmunk	MTA Hall Mid-Hall	50
Chipmunk	MTA Hall "Front Porch"	50
Chipmunk	Pipe to Absorber	50
Chipmunk	MTA Counting House	5,000

Required Surveillance

Operation of all access control interlock components shall be functionally tested at an interval no greater than 15 months.

Area radiation monitors shall be maintained and calibrated on an interval no greater than 15 months.

Response	Beam operation to the MTA will be terminated. Beam operation to the MTA will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Operation Authorization Document

Applicability	During beam operations to the MTA segment of the Fermilab Main Accelerator.
Basis	To summarize the bounding conditions for safe operation of the MTA, and to provide explicit approval for operations of the MTA.
Credited Control	An approved MTA Beam Permit & Running Condition shall be issued prior to MTA beam operations.
Required Surveillance	The MTA Beam Permit and Running Condition shall be verified annually, not to exceed twelve (12) months.
Response	Beam operation to the MTA will be terminated. Beam operation to the MTA will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Search and Secure

Applicability	Prior to beam operations to the MTA segment of the Fermilab Main Accelerator.
Basis	To ensure protection against inadvertent access into the MTA enclosure during beam operations
Credited Control	A valid Search & Secure shall be performed by the AD Operations Department.
Required Surveillance	None
Response	Beam operation to the MTA will be terminated immediately once a USI Screening determines that a discovered condition warrants USI Evaluation. Beam operation to the Linac will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Staffing

Applicability	During beam operations to the MTA segment of the Fermilab Main Accelerator.

Basis	To ensure accelerator operations are disabled and initiate an immediate response in the event of a determined ASE violation.
Credited Control	The following staffing shall be in place during applicable beam operation: • At least one member of the AD Operations Department who has achieved the rank of Operator II or higher shall be on shift. • At least one member of the AD Operations Department shall be present in the Main Control Room (MCR).
Required Surveillance	none
Response	Beam operation to the MTA will be terminated. Beam operation to the MTA will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.

Administrative – Accelerator Operating Parameters

Applicability	During beam operations to the MTA segment of the Fermilab Main Accelerator.
Basis	To ensure operations within bounding conditions used in the MCI analysis.
Credited Control	The following intensity shall not be exceeded: 2.58e18 protons/hr
Required Surveillance	none
Response	Beam operation to the MTA will be terminated. Beam operation to the MTA will not resume until approval is received from the AD Associate Lab Director and the DOE Field Element Manager.