FESHM 2010: PLANNING AND REVIEW OF ACCELERATOR FACILITIES AND THEIR OPERATIONS

Revision History

Author	Description of Change	Revision Date

M. Schoell	• Updated to reflect updated DOE O 420.2D and updated programs
	  ○ Updated/expanded existing sections:
	  ▪ Definitions (Section 2.0)
	  ▪ USI Process (Section 3.1)
	  ▪ Determination of Applicability (Section 3.2)
	  ▪ Hazard Analysis (Section 3.3)
	  ▪ Safety Assessment Document (SAD) (Section 3.4)
	  ▪ SAD Guidelines (Section 5.1)
	  ○ Incorporate new sections:
	  ▪ Accelerator Safety Envelope (ASE) (Section 3.5)
	  ▪ Accelerator Readiness Review (ARR) (Section 3.6)
	  ▪ Operations (Section 3.7)
	  ▪ Accelerator Safety Order (ASO) Compliance Assurance (Section 3.8)
	  ▪ ASE Guidelines (Section 5.2)
	• Editorial updates to reflect organizational changes
	• Updated References
		May 2024

J. Donald Cossairt	• Editorial changes made to this chapter and associated forms in view of the Laboratory reorganization of ESH&Q effective June 1, 2016.	January 2017

	• Correction made to acknowledge the replacement of the Shielding Assessment Review Subcommittee with the Shielding Assessment Review Panel of the Radiation Safety Subcommittee. • Institution of SRSO approval of applications of the exemptions of DOE Order 420.2C. • Elimination of the term PSAD and all discussions of Preliminary Safety Assessment Documents. • Procedural changes made based on practical experience of implementation. • Clarified approval process for UDI Determination form • Forms posted as separate ESH&Q Docdb entries • Other editorial changes, corrections, etc.	
J. Donald Cossairt	• Editorial changes made to this chapter and associated forms in view of the Laboratory reorganization of ESH&Q effective July 1, 2015. • Corrected reference to the companion DOE Guidance document to DOE O420.2C to reflect the current DOE G 420.2-1A. This guidance document replaces one that was in effect at the time of the previous revision of this chapter. This is also an editorial change.	July 2015
J. Donald Cossairt	• Incorporate extensive changes intended to meet the revised requirements of DOE O420.2C (7-21-2011)	May 2013

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1.0 INTRODUCTION AND SCOPE

This FESHM chapter describes the formal policies, programs, and practices established by the Laboratory to assure that accelerator facilities and their operations comply with Fermilab Environment, Safety and Health requirements and with DOE O 420.2D, *Safety of Accelerator Facilities* (9-9-2022). This Chapter applies to all Fermilab accelerators that operate above 10 MeV (see R.P. Form 135 *List of Accelerators)*.

This Chapter shall be applied to new accelerators or when modifications, including decommissioning, occur to existing accelerators. The level of detail required in the Safety Assessment Documents (SADs) that are developed as part of this process and the amount of resources expended in the Accelerator Readiness Review (ARR) and its accompanying documentation should be commensurate with the programmatic importance and potential ES&H impact of the facility and its activities. The Fermilab Environment, Safety and Health Manual (FESHM), inclusive of the Fermilab Radiological Control Manual (FRCM), and the Fermilab Quality Control Manual (QAM) specify a set of physical and administrative conditions that define the bounding conditions for safe operation of accelerator facilities or portions thereof.

Fermilab utilizes a single SAD for all of its facilities. Individual analyses are written as modules (i.e., chapters) of the overall SAD. See the Fermilab SAD Table of Contents for a list of areas included in the Fermilab SAD.

Most accelerator improvements and the design, construction, and decommissioning of them are conducted as part of projects of varying sizes and funding types. FESHM 2001 summarizes environment, safety, and health requirements that pertain to all Fermilab projects and identifies other types of work planning tasks that shall be performed for all projects, including accelerator projects. Documentation of requirements related to work involving ionizing radiation are covered in the FRCM.

The Fermilab Director, as advised by the Fermilab Chief Safety Officer, determines the applicability of this Chapter and notifies the responsible division/directorate(s) and gives guidance on the level of details required. Divisions and Directorates are responsible for maintaining their SAD Chapter(s) and associated Accelerator Safety Envelope (ASE)s up-to-date by revising them when necessary. SAD Chapters shall be reviewed not less frequently than every five (5) years. At a minimum, all SAD Chapters shall have the Document number, Revision Date, and Issue Date in accordance with Director's Policies. Revised SADs and ASEs shall be reviewed and approved in accordance with the procedures of this chapter. SADs and ASEs are reviewed by the Safety Assessment Document Review Subcommittee of the Fermilab ES&H Committee (FESHCom). SADs are approved by the Fermilab Director and the ASEs are approved by the DOE-FSO. The charter of this subcommittee is at: FESHCom SAD Review Subcommittee Charter.

SADs commonly summarize and reference multiple types of analyses for prompt ionizing radiation, including: Maximum Credible Incident (MCI) analysis, a radiation shielding assessment, post-assessment documents, and/or post-assessment memos. Requirements and guidance concerning the shielding of ionization radiation and the preparation and approval of shielding assessments are

described in FRCM Chapter 8. MCI Analyses are reviewed and approved by the Senior Radiation Safety Officer (SRSO). Shielding assessments are reviewed by the Shielding Assessment Review Panel (SARP) of the Fermilab Radiation Safety Subcommittee (RSSC), as specified in its charter, and approved by the SRSO. The charter of this subcommittee is at: https://esh-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=812.

It is not uncommon for accelerator segments/facilities to exist in "standby" or "idle" conditions for lengthy periods of time upon completion of their mission pending final decisions concerning their future use or disposition. The SAD Chapters that address these segments/facilities shall be revised or updated with addenda, and reviewed and approved in accordance with the provisions of this chapter, to assure proper assessment and mitigation of the hazards during this post-operational stage. The documentation, if appropriate, can be used to certify the termination of applicability of the SAD module.

2.0 DEFINITIONS

The following terms and/or acronyms are commonly used when discussing operation of the accelerators at Fermilab. 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 accelerators at Fermilab in italics. Definitions that are also found in the Accelerator Safety Envelopes are further identified with a cross (†).

- †*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 Component: Components used within an accelerator such as, but not limited to, radio-frequency (RF) cavities, electrostatic separators, kickers, pingers, and choppers when tested by themselves, do not by themselves meet the definition of an accelerator, although these devices may produce x-rays.

- †*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 100, 500, or 5000 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 Controls: 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.

The Credited Controls for Fermilab are:

- *Shielding*
- *Fencing*
- *Obvious and Operating Barriers to ensure only authorized access*
- *Radiation Safety Interlock System (RSIS)*
- *Oxygen Deficiency Hazard (ODH) Safety System (in applicable accelerator facilities)*
- *Operation Authorization Document*
- *Staffing*
- *Accelerator Operating Parameter*

- †*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.

- Exclusion Area: An area, generally an accelerator or beamline enclosure, subject to radiological and/or other hazards to which access during accelerator or beamline operations is prohibited and prevented by means a system of locks, interlocks, and passive shielding.

- Experimenters: All persons directly involved in experimental efforts at the accelerator utilizing the accelerator or its beams, including visiting scientists, students and others who may not be employees of Fermi Research Alliance, the DOE Management and Operating (M&O) contractor for Fermilab.

- Hazard: A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to a facility or to the environment.

- Hazard Analysis (HA): A tool used to plan work not specifically otherwise addressed by this chapter. See FESHM 2060.

- Idle State: A condition in which a facility is not scheduled for future operation and is being maintained in a safe condition pending plans for repurposing and/or demolition.

- Machine Controls: Machine controls are other administrative controls and machine protection systems that may be used in addition to credited controls defined here to limit the duration of beam loss. These and their use in the shielding analysis are described in Appendix 2 of FRCM Chapter 2.

- †Maximum Operating Intensity: The maximum intensity a given segment is able to operate at. This value is used in the Maximum Credible Incident (MCI) analysis.

- †Nominal Operating Intensity: The intensity a given segment typically operates at, which is ~5% lower than the intensity identified by the machine and/or Project, supported by the Shielding Assessment, in order to accommodate potential fluctuation in beam intensity due to changes in efficiency.

- Operations Envelope: A set of physical and administrative conditions that may be defined outside of the ASE for individual subsets of operations or modules of the accelerator/storage ring beam. The operations envelope defines nominal operating parameters beyond which the operating procedures would require adjustments to be made. An operations envelope serves to prevent the ASE from being exceeded. Variations of operating parameters within an appropriate operations envelope are considered within the scope of normal operations. Variation outside the operations envelope but within the ASE merits appropriate attention; it does not require termination of activities or notification of DOE.

- Preliminary Hazard Analysis Report (PHAR): A preliminary formal review document to analyze Laboratory projects, operations and experiments for possible hazards and possible ways to mitigate them. The PHAR is one of the requirements of DOE O413.3B, *Program and Project Management for the Acquisition of Capital Assets,* 11-29-2010.

- Preliminary Hazard Assessment Document (PHAD): A synonym of PHAR. The two terms are equivalent for purposes of this Chapter.

- Preliminary Safety Assessment Document (PSAD): The name of a formerly used preliminary formal review document to analyze Laboratory projects, operations and experiments for possible hazards and possible ways to mitigate them with a focus on accelerator-specific topics. For a major project, the function of the PSAD is now in the Preliminary Hazard Analysis Report (PHAR) process established to also meet the requirements of DOE O413.3B, Chg 7, *Program and Project Management for the Acquisition of Capital Assets,* 06-21-2023.

- Project Leader: The individual assigned primary responsibility for the overall conduct of a given activity subject to the provisions of this chapter (FESHM 2010). This is the person to whom Fermilab management has assigned the responsibility for schedule and performance specifications and financial stewardship. This individual may also be designated the Project Manager in conformance with project management requirements specified by DOE Orders.

- †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.

- Radiation Protection Program (RPP): The documented program, approved by DOE, including but not limited to the plans, schedules, and other measures developed and implemented to achieve and ensure continuing compliance with 10 CFR Part 835 and apply the "as low as reasonably achievable" (ALARA) process to occupational and environmental radiation dose (see FRCM).

- †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.

- Routine Operation: Routine operation commences at the point where authorization has been granted either (1) because the commissioning effort is sufficiently complete to provide confidence that the hazards are both understood and acceptable and the operation has appropriate safety bounds, or (2) to permit the re-introduction of a particle beam after being directed to cease operation by DOE because of an environment, safety, or health concern that has been assessed and resolved to the satisfaction of both the Director and DOE-FSO.

- †*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.

- Standby State: A condition in which a facility or portion of a facility is presently not operational but in which operations may be resumed at an indefinite time in the future.

- †*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.

3.0 PROGRAM DESCRIPTION

The Accelerator PHAR, SAD and the associated ARR process is initiated with either a recommendation by the Chief Safety Officer to the Fermilab Director concerning the applicability of PHAR/SAD for a proposed project, operation or experiment or a similar determination by the division/directorate head(s) responsible for the activity in consultation with the Environment, Safety and Health (ES&H) Division Accelerator Safety Department**.** Often, multiple divisions/directorates may share these responsibilities. For projects of limited scope, the PHAR step may not be required. For projects for which DOE O413.3B is applicable, the PHAR process may be used and developed into the SAD. These determinations shall be documented using the ARR Determination Form posted alongside this chapter on ESH&Q DocDB at. Consistent with the requirements of FESHM Chapter 2001, the need for a PHAR shall be determined at the earliest possible stage of conceptual design. The ARR Determination forms are reviewed and approved by the Senior Radiation Safety Officer (SRSO) and the Chief Safety Officer (CSO). The Chief Safety Officer shall maintain records in the ES&H Section document database system or electronic equivalent of all completed Forms.

Following this determination of applicability, if required, the responsible division/directorate will prepare a PHAR, the approval of which allows initiation of more detailed design and/or construction.

The role of the PHAR is largely to identify the environment, safety, and health issues (i.e., hazards) that are not adequately addressed by common industrial practices performed within boundaries set by federal regulations and by standard-setting bodies (e.g., ANSI, AMSE, NFPA). The PHAR is not intended to describe all mitigation measures.

The role of the SAD is to document the measures taken to successfully mitigate these hazards and how these mitigation measures are to be folded into routine operation of the accelerator or accelerator facility. Thus, if required, the PHAR is prepared at the earliest stage of project development; when the necessary broad conceptual understanding of potential project ES&H issues of required information is available. Then, when detailed hazard analyses and mitigation methodologies are better understood (e.g., a more advanced stage of design), the SAD is prepared. The SAD shall incorporate a risk assessment conducted using a systematic methodology. The risk assignment methodology used

follows DOE-HDBD-1163-2020 *Integration of Hazard Analyses.* Completed PHARs or SADs shall be submitted to the Chair of the Safety Assessment Document Review Subcommittee either directly or via Chief Safety Officer for review.

For new projects or for those that have been significantly modified, a documented ARR, facilitated by the ES&H Division at a time prior to commissioning activities but at a sufficiently advanced stage of the project to assure validity, must be completed. The schedule for the ARR should be done with concurrence between the Chief Safety Officer, the project management leader as assigned by Fermilab management, and the hosting Division/Directorate Head. The ARR may result in a list of items that need to be completed (i.e., a so-called "punch list") before the approval to operate is granted. Upon successful completion of the review and close-out of all significant issues, approval for operations is granted via approval of the Accelerator Safety Envelope (ASE) by the DOE-FSO.

Experience has indicated that this process is greatly enhanced by timely, effective collaboration and communication between the responsible division/directorate(s) and the Safety Assessment Review Subcommittee and Shielding Assessment Review Panel along with ES&H Division. Involvement of representatives of the DOE-FSO at an early stage of project planning has also been found to be highly beneficial.

3.1 Unreviewed Safety Issue (USI)

An Unreviewed Safety Issue (USI) Form is to be completed for proposed modified activities, **this includes all DOE O413 projects**, (e.g., a significant change to operations and possibly the associated hazards), or for a previously unevaluated hazard discovered in an ongoing operation. The USI Form should be completed when there is a reasonable chance that a proposed activity or previously unevaluated hazard discovered in an ongoing operation could affect the probability or consequence of an accident from that evaluated in the Fermilab SAD or introduce an accident or malfunction of a different type than any evaluated in the SAD.

A USI may be initiated by division/directorate line managers, project managers, project engineers, system engineers, or ES&H personnel. The Screener completes the USI Screening Form providing a description of the proposed activity or discovered condition and answers a series of questions to determine if the issue should be further evaluated for a USI. If a "Yes" is answered to any of the questions, then the issue is further evaluated for a USI. If a "No" is answered to all questions, a USI does not exist and no further evaluation is required. The USI Screening form is approved by both the Screener and the Machine Owner, and is submitted to the ES&H Division for records retention.

For issues that require further USI Evaluation, the Machine Owner completes the USI Evaluation Form in consultation with the ES&H Division Accelerator Safety Department. The USI Evaluation Form asks a series or more detailed questions related to Credited Controls, accelerator specific hazards, non-accelerator specific hazards, change or introduction of new risk, etc. to determine if a USI exists. If a USI exists, the Form includes fields to identify necessary actions that need to be taken, and identifies the levels approvals necessary. Once all actions have been taken, and approvals

obtained, the issue becomes a Reviewed Safety Issue (RSI). RSIs are considered to be addenda to the SAD. The USI Evaluation Form is submitted to the ES&H Division for records retention.

If a USI is determined to exist for a proposed activity, accelerator operations with the activity complete may not commence without all necessary approvals. In cases where a change to the ASE is required, the activity may not commence without prior DOE-FSO approval of the ASE revision.

If a USI is determined to exist in an ongoing operation subsequent to the issue of a SAD, the discovery of a USI as defined by this chapter (FESHM 2010) could possibly constitute a reportable occurrence to be addressed and reported in accordance with DOE O 420.2D and FESHM 3010. Activities stopped as a result of an identified USI for a discovered condition shall not resume or commence operations without written approval of the DOE-FSO Manager.

The full USI Process is described in SAD Appendix B.2, and procedure ESH-ASD-0001 *USI Implementation Procedure*¸ provides additional detail for the various steps in the USI Process.

3.2 Determination of Applicability

In addition to the USI process, the Chief Safety Officer regularly reviews projects, operations, and experiments for applicability of the provisions of this chapter and makes corresponding recommendations to the Fermilab Director concerning DOE O 420.2D applicability.

Division/Directorate Head(s) shall inform the Chief Safety Officer of new projects, operations, and experiments that are candidates for SADs or SAD modifications at the earliest reasonable stage by completing the USI form. Fermilab-authorized operations that originate outside the Laboratory are also reviewed for applicability of the requirements of this chapter.

Additionally, devices that have applied voltage or RF and are capable of producing a Radiation Area (as defined by 10 CFR 835) shall be reviewed by the ES&H Division for applicability of DOE O 420.2D. Responsible Division/Directorate(s) shall work with ES&H Division to complete ESH-RPO-RGD-01 *Radiation Generating Devices*, and the associated R.P. Form 133 *Radiation Generating Device Checklist*, to determine if the device is a Radiation Generating Device (RGD), an equivalent accelerator, or a non-equivalent accelerator. RGDs and equivalent accelerators are managed as RGDs under 10 CFR 835, and DOE O 420.2D and this Chapter do not apply. See R.P. Form 108 for a List of Radiation Generating Devices.

Following the determination of applicability, the Chief Safety Officer notifies the responsible division/directorate(s) of the DOE O 420.2D applicability. This formal notification is not needed if the responsible organization(s) have already determined that a PHAR/SAD is to be revised or prepared. This determination and subsequent PHAR/SAD initiation must occur during the earliest phases of the activity to facilitate early hazard identification and mitigation. The documentation for the determination of applicability shall be inventoried and filed with the ES&H Division regardless of the conclusion.

A new PHAR/SAD is not required for upgrades to an existing facility or operation that are within the scope of its existing SAD. Documentation demonstrating that the upgrade is within the scope of the existing SAD shall be written by the responsible division/directorate(s) by going through the USI Process. Addenda to existing SADs provide a venue for maintaining up-to-date safety assessment documentation. SAD addenda proceed through the same approval process as does a new SAD.

3.3 Hazard Analysis

The PHAR should follow the guidelines outlined in FESHM 2001.The hazards associated with the lifecycle of the facility (i.e., 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 or transportation requirements, and packaging of samples after use in the accelerator beam) shall be identified. Additionally, hazards associated with construction and decommissioning should be identified. In general, the hazard analysis in the PHAR should start with the Written Hazard Analysis Guideline found in FESHM 2060. For large or complex projects, the Issues List is recommended for providing a technical basis for such a hazard analysis. This Issues List was originally generated as part of the Necessary and Sufficient Process carried out at Fermilab in 1995 and is the result of a comprehensive analysis of the hazards present on the Fermilab site. The Issues List can be found on the ESH&Q DocDB at: Issues List. This Issues List is a starting point; the required comprehensive analysis could identify additional issues.

Once the hazards associated with the lifecycle of the facility are identified, the applicability of the hazard shall be described, and the baseline risk, preventive and mitigative measures, and residual risk shall be determined.

For the most part, the common industrial or environmental hazards which do not pose any additional hazard by virtue of their association with the lifecycle of the facility are addressed through Common Risk Matrix Tables contained in SAD Appendix C

Preliminary analyses for ionizing radiation may be performed separately from the PHAR. Summaries of the analyses shall be incorporated into the PHAR documentation. Recognizing that the PHAR often must be written before the construction drawings are detailed enough to perform the preliminary analyses, such preliminary analyses may of necessity be “iterative” in nature, conducted concurrently with facility design. Formal radiation shielding assessments shall be conducted in accordance with provisions of FRCM Chapter 8 prior to the bidding of construction bid packages when designs are final, or very near final.

3.4 Safety Assessment Document (SAD)

3.4.1. Fermilab SAD Structure

Fermilab has one modular Safety Assessment Document (SAD), with multiple Sections and Appendices.

- Section I – Overview of Fermilab Facilities
- Section II – Support Facilities
- Section III – Fermilab Main Accelerator (Accelerator Segments)
- Section IV – Fermilab Main Accelerator (Experimental Areas and Detectors)
- Section V – FAST Accelerator
- Section VI – Test Stand Accelerators
- Section VII – Appendices
    - VII-A – Accelerator Safety Envelope
    - VII-B – Fermilab Accelerator Safety Policies & Programs
    - VII-C – Non-Accelerator Specific Hazard (NASH) Risk Matrix Tables

3.4.2. Development of Individual SAD Chapters

The SAD is developed by the Line Organization, with support from the ES&H Division. The SAD should follow the same guidelines as those given for the PHAR while documenting the mitigation of unique hazards found throughout the lifecycle of the facility. The conclusions of the SAD as a whole will support the Credited Controls specified in the associated Accelerator Safety Envelope (ASE).

The division/directorate(s) commonly choose to review new projects or facilities by means of one or more safety review panels. Such safety panels may consist of laboratory staff or experts from outside the Laboratory. The responsible division/directorate may request assistance from the Fermilab ES&H Committee (FESHCom) and its subcommittees to review projects, answer specific safety questions, recommend solutions to ES&H problems, assist in setting ES&H policy, or evaluate requests for exemptions from existing policies. The results of these reviews should be incorporated into SAD documentation.

Summaries of the hazard analysis, described in Section 3.3, shall be incorporated into SAD documentation, and the Risk Matrix table shall be included as an appendix to the specific SAD Chapter.

The Maximum Credible Incident (MCI) due to prompt-ionizing radiation shall be determined and analyzed for each accelerator or accelerator segment. The MCI is the maximum parameters capable of the machine (e.g., intensity) and the maximum duration of an accident (e.g., beam loss). The MCI is then analyzed to determine potential unmitigated dose, identify Credited Controls, and determine mitigated dose. Acceptable mitigated dose levels are specified in SAD Section I Chapter 4. The MCI may be performed separately from the SAD. However, summaries of the analysis shall be incorporated into the SAD documentation. The Credited Controls used in the MCI are further included in the applicable ASE.

Shielding assessments are also performed for ionizing radiation to determine controls necessary for ALARA, 10 CFR 835, and DOE O 458.1. Any controls identified in the Shielding Assessment beyond the Credited Controls determined through the MCI analysis are considered to be Defense-in-Depth controls. Shielding assessments for ionizing radiation may be performed separately from the SAD. However, summaries of the analysis shall be incorporated into the SAD documentation. Radiation shielding assessments shall be conducted in accordance with provisions of FRCM Chapter 8.

ODH analyses are performed in accordance with FESHM 4240. For applicable accelerator facilities that have ODH hazards, the ODH safety system components that are necessary to detect and alert personnel to an ODH environment shall be identified as Credited Controls.

Credited Controls identified through applicable MCI or ODH analyses are summarized in the SAD and identified in the ASE. In the field, these controls follow the standard requirements specified in FRCM and FESHM, and additionally have Credited Control labeling applied (where it's safe to do so). The Credited Controls are subject to configuration management via the USI Process.

In order to ensure consistency between the Chapters, the individual SAD Chapter outline is included in Section 5.1.

3.4.3. Review of the SAD

The Safety Assessment Document Review Subcommittee of the Fermilab ES&H Committee (FESHCom) is responsible for reviewing the results of each SAD Chapter for completeness and compliance with this FESHM Chapter as specified in more detail in its charter. As part of its duties, this subcommittee is charged with submitting reports to the Chief Safety Officer recommending acceptance or rejection for cause of SADs based on the consensus of the subcommittee. For SADs concerned with strategic or major system projects (as defined by DOE) or line item projects, one or more representatives of DOE-FSO may be included as observers on the assigned review team preparatory to the official transmittal for concurrence by DOE-FSO. The list of reviewers of each SAD shall be documented along with any review comments they contribute.

3.4.4. Approval of the SAD

The Chief Safety Officer coordinates the reviews of PHARs and SADs and their approval by the Fermilab Director.

. Normally, PHARs/PHADs are not formally transmitted to the DOE-FSO for concurrence but might be sent to DOE-FSO for informational purposes as part of project oversight activities.

PHAR/SAD approval requires the following signatures:

- Individual SAD Chapter, in any order
    - SAD Review Subcommittee Chair

    - Line Organization Owner
    - ES&H Division Accelerator Safety Department Head
- Full Fermilab SAD, once all included individual Chapters are approved, in the following order
  1. Associate Lab Director(s) and Senior Director(s) that own accelerator facilities, in any order
     - Accelerator Directorate
     - Applied Physics & Superconducting Technology Directorate
     - Particle Physics Directorate
     - Infrastructure Services Division
     - Environment, Safety & Health Division
  2. Fermilab Director

The SAD shall be sent to the DOE-FSO Manager for concurrence along with the request for approval of the ASE before commissioning or operations ensue. This formal transmittal should occur after all signatures are obtained, and the SAD is fully approved by the Fermilab Director. If no comments or replies are received within 30 calendar days, it will be assumed that the SAD is sufficient unless the DOE-FSO Manager has established a different review schedule. This comment period will normally be 15 calendar days provided that a SAD that has undergone preliminary review by the ES&H Division, complete with proposed ASE, is informally provided to the DOE-FSO Manager at least 30 calendar days prior to the formal submittal of the signed, completed SAD and ASE

3.5 Accelerator Safety Envelope (ASE)

3.5.1. Fermilab ASE Structure

An Accelerator Safety Envelope (ASE) shall be developed for each accelerator at Fermilab. ASEs are maintained in Appendix A of the Fermilab SAD. Each ASE shall include the following sections:

- Section 1 Introduction and Scope
- Section 2 Select Definitions and Acronyms
- Section 3 Description of Credited Controls
- Section 4 ASE Violation Determination and Actions
- Section 5 Configuration Management for Credited Controls
- Section 6 Unreviewed Safety Issue (USI) Process
- Section 7 Summary of Credited Controls for [all Segments of] the Accelerator

3.5.2. Development of Individual ASEs

The ASE is developed by the ES&H Division Accelerator Safety Department and the Line Organization. Sections 2-6 of the ASE are common information included in each SAD. Sections 1 and 7 are unique to the applicable accelerator.

Section 7 of the ASE describe the Credited Controls, as determined by the MCI and discussed in the SAD Chapter. For each Credited Control, the following shall be specified: applicability, basis, Credited Control, required surveillance, response.

In order to ensure consistency between the ASEs, the individual ASE outline is included in Section 5.2.

3.5.3. Review of the ASE

The Safety Assessment Document Review Subcommittee of the Fermilab ES&H Committee (FESHCom) is responsible for reviewing the ASE for completeness and compliance with this FESHM Chapter as specified in more detail in its charter. As part of its duties, this subcommittee is charged with submitting reports to the Chief Safety Officer recommending acceptance or rejection for cause of SADs based on the consensus of the subcommittee. For ASEs concerned with strategic or major system projects (as defined by DOE) or line item projects, one or more representatives of DOE-FSO may be included as observers on the assigned review team preparatory to the official transmittal for concurrence by DOE-FSO. The list of reviewers of each ASE shall be documented along with any review comments they contribute.

3.5.4. Approval of the ASE

The Chief Safety Officer coordinates the reviews of ASEs and their approval by the Fermilab Director and DOE-FSO Manager.

Following completion of the Fermilab review, all ASEs are transmitted to DOE-FSO for written approval.

ASE approval and approval to commence commissioning/operation requires the following signatures in the following order:

1. Line Organization, in any order
    - SAD Review Subcommittee Chair
    - Division/Directorate Associate Lab Director or Senior Director
    - ES&H Division Accelerator Safety Department Head
2. Fermilab Director
3. DOE-FSO Manager

The ASE shall be sent to the DOE-FSO Manager for approval before commissioning or operations ensue. This formal transmittal should occur once signatures in steps 1 and 2 above are obtained and prior to conducting the Accelerator Readiness Review. ASEs must be approved by DOE in accordance with DOE O420.2D. DOE-FSO Manager of the ASE typically occurs after the completion of the ARR.

3.6 Accelerator Readiness Review (ARR)

3.6.1. ARR Determination

The Accelerator Readiness Review (ARR) Determination Form shall be used to document the determined level of review for a given scope of activity, based on various considerations derived from DOE O 420.2D and operational experience. The ARR Determination Form ensures consistency in determinations between multiple division/directorate(s) and in various periods of time. It also allows for documenting the justification for the determination.

The ARR Determination Form is completed by the Assigned Radiation Safety Officer (RSO), Division Safety Officer (DSO), Activity Owner, and Division/Directorate Head. The ARR Determination Form is then approved by the SRSO and CSO.

3.6.2. Internal Readiness Review (IRR)

Although not explicitly required per DOE O 420.2D, conducting an Internal Readiness Review (IRR) prior to conducting an Accelerator Readiness Review (ARR) is highly encouraged, and aligns with best community practice.

IRRs may be limited scope reviews, and may be made up of either internal or external reviewers.

3.6.3. Accelerator Readiness Review (ARR)

Accelerator Readiness Reviews (ARRs) shall be conducted prior to commissioning and operations of new or modified accelerators. ARRs are intended to demonstrate readiness for operations, and encompasses the people, process, and equipment in place to ensure safe operations of the accelerator to ensure adequate protection of workers, public, and the environment. All programmatic elements described in DOE O 420.2D should be reviewed in an ARR. Select elements may be omitted if they underwent a recent review, and this shall be justified and documented in the ARR Determination Form.

ARR review teams shall have, at minimum, an external review Chair. The remainder of the ARR review team should be comprised of internal and/or external subject matter experts (SMEs) commensurate with the scope of the review. The review team should be identified and agreed upon by the owning division/directorate and ES&H Division. For Accelerator Readiness Reviews concerned with strategic or major system projects (as defined by DOE) or line item projects, one or more representatives of DOE-FSO may be included as observers on the assigned review team.

Approval to commence commissioning/operation requires DOE-FSO approval, typically provided by their approval of the applicable ASE.

3.7 Operations

During accelerator operations, the applicable ASE shall be followed, with required Credited Controls in place and surveilled as specified. Any deviation shall be considered a Discovered Condition and warrant review through the USI Process. Any Discovered Condition found to have violated the ASE

shall result in immediate termination of the affected accelerator (or accelerator segment). Resumption of operations following an ASE violation requires approval from the DOE-FSO Manager. Additional details for response to ASE violations is described in the applicable ASE.

At the conclusion of operation, accelerator facilities may go into standby/non-operational/idle mode. Official decommissioning requires DOE-FSO approval. FESHM 8070 provides Fermilab requirements on this topic.

3.8 Accelerator Safety Order (ASO) Compliance Assurance

Program elements described in this Chapter, including SAD Chapters and ASEs, shall be reviewed at a minimum frequency of five (5) years. It is encouraged to follow the triennial review practice used for 10 CFR 835 reviews, and conduct DOE O 420.2D program element reviews triennially to ensure compliance with Order requirements. DOE O 420.2D program element reviews will be facilitated by the ES&H Division and documented in the Fermilab Assessment Database.

Internal Readiness Reviews (IRRs) and Accelerator Readiness Reviews (ARRs) are conducted as necessary. IRRs and ARRs will also be facilitated by the ES&H Division and documented in the Fermilab Assessment Database.

Recommendations for DOE O 420.2D program element reviews, IRRs, and ARRs will be documented and tracked to completion in the Fermilab issues tracking database (iTrack).

3.9 Documentation

All documentation generated in accordance with this Chapter (e.g., USI Screening Form, USI Evaluation Form, ARR Determination Form, SAD Chapter, ASE, ARR reports, etc.) shall be maintained by the ES&H Division Accelerator Safety Department for 75 years or the life of the facility.

4.0 REFERENCES

- DOE O 420.2D *Safety of Accelerators*, 9-9-2022. Current weblink: https://www.directives.doe.gov/directives-documents/400-series/0420.2-BOrder-d
- DOE-HDBD-1163-2020 *Integration of Hazard Analyses*, October 2020. Current weblink: https://www.standards.doe.gov/standards-documents/1100/1163-bhdbk-2020
- Fermi National Accelerator Laboratory Unreviewed Safety Issue (USI) Program. Appendix B.2 of the Fermilab Safety Assessment Document.
- Fermilab Environment, Safety and Health Manual (FESHM). Current weblink: https://eshq.fnal.gov/manuals/feshm/
- Fermilab Radiological Control Manual (FRCM). Current weblink: https://eshq.fnal.gov/manuals/frcm/
- USI Forms, located in ESH DocDB 3361
- ARR Determination Form, located in ESH DocDB 7026
- DOE O 413.3B Chg 7
- R.P. Form 135 *List of Accelerators*, located in ESH DocDB 7481
- Issue List, located in ESH DocDB 776

5.0 TECHNICAL APPENDICES

5.1 SAD Guidelines

The SAD documents may contain references to other SAD Chapters as appropriate rather than repeating large portions of an existing document. Summaries of reference documents (e.g., MCI analysis, Shielidng Analysis) should be included where appropriate.

The SAD should be written in accord with the following outline, including "N/A" for non-applicable sections rather than deleting the section:

1. Introduction
   - 1.1. Purpose/Function
   - 1.2. Current Status
   - 1.3.Description
   - 1.4.Location
   - 1.5.Management Organization
   - 1.6. Operating Modes
   - 1.7. Inventory of Hazards
2. Safety Assessment
   - 2.1. Radiological Hazards
     - 2.1.1. Prompt Ionizing Radiation
     - 2.1.2. Residual Activation
     - 2.1.3. Groundwater Activation
     - 2.1.4. Surface Water Activation
     - 2.1.5. Radioactive Water (RAW) Systems
     - 2.1.6. Air Activation
     - 2.1.7. Closed Loop Air Cooling
     - 2.1.8. Soil Interactions
     - 2.1.9. Radioactive Waste
     - 2.1.10. Contamination
     - 2.1.11. Beryllium-7
     - 2.1.12. Radioactive Sources
     - 2.1.13. Nuclear Material
     - 2.1.14. Radiation Generating Devices (RGDs)
     - 2.1.15. Non-Ionizing Radiation Hazards
   - 2.2. Toxic Materials
     - 2.2.1. Lead Shielding
     - 2.2.2. Beryllium
     - 2.2.3. Fluorinert & Its Byproducts
     - 2.2.4. Liquid Scintillator Oil
     - 2.2.5. Pseudocumene
     - 2.2.6. Ammonia
     - 2.2.7. Nanoparticle Exposure
   - 2.3. Flammables and Combustibles
     - 2.3.1. Combustible Materials
     - 2.3.2. Flammable Materials

- 2.4. Electrical Energy
  - 2.4.1. Stored Energy Exposure
  - 2.4.2. High Voltage Exposure
  - 2.4.3. Low Voltage, High Current Exposure
- 2.5. Thermal Energy
  - 2.5.1. Baekouts
  - 2.5.2. Hot Work
  - 2.5.3. Cryogenic Liquids
- 2.6. Kinetic Energy
  - 2.6.1. Power Tools
  - 2.6.2. Pumps and Motors
  - 2.6.3. Motion Tables
  - 2.6.4. Mobile Shielding
- 2.7. Potential Energy
  - 2.7.1. Crane Operations
  - 2.7.2. Compressed Gasses
  - 2.7.3. Vacuum/Pressure Vessels/Pumps
  - 2.7.4. Vacuum Pumps
  - 2.7.5. Material Handling
- 2.8. Magnetic Fields
  - 2.8.1. Fringe Fields
- 2.9. Other Hazards
  - 2.9.1. Confined Spaces
  - 2.9.2. Noise
  - 2.9.3. Silica
  - 2.9.4. Ergonomics
  - 2.9.5. Asbestos
  - 2.9.6. Working at Heights
  - 2.9.7. Lithium
- 2.10. Access & Egress
  - 2.10.1. Life Safety Egress
- 2.11. Environmental
  - 2.11.1. Hazard to Air
  - 2.11.2. Hazard to Water
  - 2.11.3. Hazard to Soil

3. Maximum Credible Incident Scenario(s) for the Accelerator Specific Hazard(s)
   - 3.1. Definition of a Maximum Credible Incident
     - 3.1.1. Radiological Hazard
4. Summary of Credited Controls
   - 4.1. Passive Credited Controls
     - 4.1.1. Shielding
       - 4.1.1.1. Permanent Shielding Including Labyrinths
       - 4.1.1.2. Movable Shielding
       - 4.1.1.3. Penetration Shielding

5.2 ASE Guidelines

The ASE should be written in accord with the following outline, deleting any non-applicable Credited Controls within Section 7 (Section 7.1-7.8):

1. Introduction and Scope
2. Select Definitions and Acronyms
3. Description of Credited Controls
   - 3.1.Passive
     - 3.1.1. Shielding
     - 3.1.2. Fencing
     - 3.1.3. Obvious and Operating Barriers
   - 3.2. Active Engineered
     - 3.2.1. Radiation Safety Interlock System (RSIS)
     - 3.2.2. ODH Safety System
   - 3.3. Administrative
     - 3.3.1. Operation Authorization Document
     - 3.3.2. Staffing
     - 3.3.3. Accelerator Operating Parameters
4. ASE Violation Determination and Actions
   - 4.1. Determination
   - 4.2. Actions
5. Configuration Management of Credited Controls
6. Unreviewed Safety Issue (USI) Process
7. Summary of Credited Controls for [all Segments of] the Accelerator
   - 7.1. Passive – Shielding
     - 7.1.1. Applicability
     - 7.1.2. Basis
     - 7.1.3. Credited Control
     - 7.1.4. Required Surveillance
     - 7.1.5. Response
   - 7.2. Passive – Fencing
     - 7.2.1. Applicability
     - 7.2.2. Basis
     - 7.2.3. Credited Control
     - 7.2.4. Required Surveillance
     - 7.2.5. Response
   - 7.3. Passive – Obvious and Operating Barriers
     - 7.3.1. Applicability
     - 7.3.2. Basis
     - 7.3.3. Credited Control
     - 7.3.4. Required Surveillance
     - 7.3.5. Response
   - 7.4. Active – Radiation Safety Interlock System (RSIS)