

Phased Review Approach to Ensure Readiness to Operate Under DOE O 420.2D

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Introduction

Fermilab originally submitted the “DOE O 420.2D, *Safety of Accelerators, Fermilab Implementation Plan*” on November 2, 2022, with a revised plan submitted November 18, 2022. The updated plan was approved by the Fermilab Site Office (FSO) Manager on December 20, 2022. Subsequently, two letters have been received by Fermilab from FSO indicating a number of comments to resolve related to the SAD and ASE. Additionally, two external reviews have been conducted to externally validate the updated SAD and ASE and assist with DOE O 420.2D implementation efforts. All of the findings, comments and recommendations gathered from the various avenues have been addressed, and Fermilab has updated the plan and timeline to ensure successful implementation and include a series of readiness reviews throughout the process.

A series of reviews, both Internal Readiness Reviews (IRRs) and Accelerator Readiness Reviews (ARRs), will be conducted. For the Fermilab Main Accelerator, operations for all un-modified segments¹ will resume following the applicable IRR, once any pre-start recommendations are complete and the ASE has been approved. Operations of the modified segment² will resume following the ARR, once any pre-start recommendations are complete and the ASE has been approved. Continued operations of the FAST Accelerator under DOE O 420.2C, and continued operations of the CMTS1, PIP2IT and VTS accelerators as Radiation Generating Devices (RGDs), has been permitted while the various reviews are being conducted. At the conclusion of the ARR, the FAST, CMTS1, PIP2IT and VTS Accelerators will be operational under DOE O 42.02D. See references [1] through [3].

Updated Plan

High-level Timeline

A resource loaded Project Schedule has been developed for the SAD/ASE Update project, and includes details for review schedule, closing of recommendations, final ASE approval, and accelerator operations. Below is a high-level overview of timeline for conducting the various reviews and intended operations.

Fermilab Main Accelerator

- IRR #1a November 30-December1, 2023
- IRR #1b January 9-11, 2024
- IRR #1c/1d January 23-25, 2024

¹ Un-modified segments include: Linac, MTA, Booster, 8 GeV, Booster Neutrino Beam (BNB), Main Injector, Recycler, Neutrinos from the Main Injector (NuMI), Muon Campus, Switchyard and Meson.

² The modified segment is Neutrino.

- ARR #1 February 13-15, 2024
- Operations
 - 1a: Linac & MTA: January 2, 2024 (following IRR #1a)
 - 1b: Booster, 8 GeV, BNB, Main Injector/Recycler, NuMI: February 7, 2024 (following IRR #1b)
 - 1c: Muon Campus, Switchyard Primary, Meson: February 19, 2024 (following IRR #1c)
 - 1d: Neutrino Muon: March 25, 2024 (following ARR #1)

FAST Accelerator

- IRR #2 January 30-February 1, 2024
- ARR #2 February 20-22, 2024
- Operations March 15, 2024

Test Stand Accelerators (CMTS1, PIP2IT, VTS, STC, HTS2)

- IRR #3 February 6-8, 2024
- ARR #3 February 27-29, 2024
- Operations March 22, 2024

Review Schedule and Scope

The series of readiness reviews will be divided into three main phases: (1) Fermilab Main Accelerator, (2) FAST Accelerator, and (3) Test Stand Accelerators. Each phase will have one or more Internal Readiness Review (IRR) focused on the updated SAD Chapter(s) and ASE(s), with a final full Accelerator Readiness Review (ARR) to ensure readiness for operation of the applicable accelerator(s) under DOE O 420.2D. The ARRs will include all elements required by the Order.

For the Fermilab Main Accelerator, since the major changes being reviewed are only in the SAD and ASE, and no changes were made to people/processes or the equipment, segments will resume operations following the IRR. The exception to this will be the Neutrino Muon beamline, where there have been changes made to people/processes and equipment. Review of the SAD and ASE applicable to Neutrino Muon will still occur during the IRR #1c/1d, however operations will not resume to this segment until following the full ARR #1. See ARR Determination Forms [4] through [10].

For the FAST Accelerator, since the major changes being reviewed are only in the SAD and ASE, operations has been permitted to continue during the course of the reviews. At the conclusion of the reviews for FAST, the FAST Accelerator will be operational under DOE O 420.2D. See ARR Determination Forms [11] and [12].

For the Test Stand Accelerators, since no major changes have been made to the devices or the physical controls, operations have been permitted to continue during the course of the reviews. At the conclusion of the reviews for the Test Stand Accelerators, the CMTS1, PIP2IT, and VTS Accelerators will be operational under DOE O 420.2D. See ARR Determination Forms [13] and [14].

Phase 1 – Fermilab Main Accelerator

- IRR #1a – Common Areas, Support Facilities, Linac, and 400 MeV Test Area (MTA)
 - SAD Section I – Overview of Fermilab Facilities
 - I-1 *Executive Summary*

- I-2 *Introduction*
 - I-3 *Site, Facility Design Criteria and Operations*
 - I-4 *Safety Assessment*
 - I-5 *Accelerator Safety Envelope Basis*
 - I-6 *Environmental Monitoring*
 - I-7 *Quality Assurance*
 - I-8 *Post-Operations Planning*
 - I-9 *Acronyms*
 - I-10 *References*
- SAD Section II – Support Facilities
 - II-1 *Railhead*
 - II-2 *Radiation Protection Calibration Facility (RPCF)*
 - II-3 *Radionuclide Analysis Facility (RAF)*
 - II-4 *Waste Handling Facilities*
 - II-5 *Applied Physics & Superconducting Technology Facilities*
 - II-6 *Shipping and Receiving Operations*
 - II-7 *Other Radioactive Material Storage Areas*
- SAD Section III – Fermilab Main Accelerator – Accelerator Segments
 - III-1 *Linac*
 - III-2 *400 MeV Test Area (MTA)*
- SAD Appendix A – Accelerator Safety Envelopes
 - VII-A.1 *Accelerator Safety Envelope – Fermilab Main Accelerator*
 - *Linac and MTA portions only
- SAD Appendix B – Fermilab Accelerator Safety Policies & Programs
 - VII-B.1 *Fermilab Shielding Policy*
 - VII-B.2 *Fermilab Unreviewed Safety Issue (USI) Process*
- SAD Appendix C – Non-Accelerator Specific Hazard (NASH) Risk Matrix Tables
 - VII-C.1 *Non-Ionizing Radiation*
 - VII-C.2 *Toxic Materials*
 - VII-C.3 *Flammable and Combustible Materials*
 - VII-C.4 *Electrical Energy*
 - VII-C.5 *Thermal Energy*
 - VII-C.6 *Kinetic Energy*
 - VII-C.7 *Potential Energy*
 - VII-C.8 *Magnetic Fields*
 - VII-C.9 *Other Hazards*
 - VII-C.10 *Access & Egress*
 - VII-C.11 *Environmental*
- IRR #1b – Booster, 8 GeV, Booster Neutrino Beam (BNB), BNB Experiments, Main Injector, Recycler, Neutrinos from the Main Injector (NuMI), and NuMI Experiments
 - SAD Section III – Fermilab Main Accelerator – Accelerator Segments
 - III-4 *Booster*
 - III-5 *8 GeV Line*
 - III-6 *Booster Neutrino Beam (BNB)*

- III-7 *Main Injector/Recycler*
 - III-8 *Neutrinos from the Main Injector (NuMI)*
 - SAD Section IV – Fermilab Main Accelerator – Experimental Areas and Detectors
 - IV-4 *MiniBooNE Detector*
 - IV-5 *NOvA Detector*
 - IV-6 *Main Injector Neutrino Oscillation Search (MINOS) Hall Detectors*
 - IV-7 *Short Baseline Neutrino Experimental Areas (SBND, MicroBooNE & ICARUS Experiments)*
 - SAD Appendix A – Accelerator Safety Envelopes
 - VII-A.1 *Accelerator Safety Envelope – Fermilab Main Accelerator*
 - *Booster, 8 GeV, BNB, Main Injector, Recycler, and NuMI portions only
- IRR #1c & IRR #1d – Muon Campus, Muon Campus Experiments, SwitchYard Primary, Meson Line, Meson Line Experiments, Neutrino Muon Line, and Neutrino Muon Line Experiments
 - SAD Section III – Fermilab Main Accelerator – Accelerator Segments
 - III-10 *Muon Campus*
 - III-12 *Switchyard*
 - III-13 *Meson*
 - III-14 *Neutrino*
 - SAD Section IV – Fermilab Main Accelerator – Experimental Areas and Detectors
 - IV-3 *Meson Switchyard 120 Experimental Areas*
 - IV-9 *Neutrino Switchyard 120 Experimental Areas*
 - SAD Appendix A – Accelerator Safety Envelopes
 - VII-A.1 *Accelerator Safety Envelope – Fermilab Main Accelerator*
 - *Muon Campus, SwitchYard Primary, Meson, and Neutrino portions only
- ARR #1 – Fermi Main Accelerator
 - DOE O 420.2D Required Elements
 - Safety Assessment Document (SAD)
 - Accelerator Safety Envelope (ASE)
 - Clearly Defined Roles & Responsibilities
 - Listing of Accelerators and Exemptions/Equivalencies
 - USI Program
 - ARR Process
 - Contractor Assurance System (CAS)
 - Internal Assessment Process
 - Configuration Management Program
 - Readiness of People, Processes, and Equipment
 - People
 - Training & Qualifications
 - Roles & Responsibilities
 - Processes and Documentation
 - SAD Chapters reviewed in IRR #1a, IRR #1b, IRR #1c/1d
 - ASE – Fermilab Main Accelerator
 - *full ASE
 - Accelerator Operations Related Procedures

- USI Process
- Configuration Management
- CAS
- Shielding Assessments
- ODH Analysis
- Equipment
 - Beamline Equipment
 - Credited Controls

Phase 2 – FAST Accelerator

- IRR #2
 - SAD Section V – FAST Accelerator
 - *V-1 Fermilab Accelerator Science & Technology (IOTA/FAST) Electron Injector*
 - SAD Appendix A – Accelerator Safety Envelopes
 - *VII-A.2 Accelerator Safety Envelope – FAST Accelerator*
- ARR #2
 - DOE O 420.2D Required Elements
 - Safety Assessment Document (SAD)
 - Accelerator Safety Envelope (ASE)
 - Clearly Defined Roles & Responsibilities
 - Listing of Accelerators and Exemptions/Equivalencies
 - USI Program
 - ARR Process
 - Contractor Assurance System (CAS)
 - Internal Assessment Process
 - Configuration Management Program
 - Readiness of People, Processes, and Equipment
 - People
 - Training & Qualifications
 - Roles & Responsibilities
 - Processes and Documentation
 - SAD Chapters reviewed in IRR #2
 - ASE – FAST Accelerator
 - Accelerator Operations Related Procedures
 - USI Process
 - Configuration Management
 - CAS
 - Shielding Assessments
 - ODH Analysis
 - Equipment
 - Beamline Equipment
 - Credited Controls

Phase 3 – Test Stand Accelerators

- IRR #3
 - SAD Section VI – Test Stand FAST Accelerators
 - VI-2 *Cryomodule Test Stand (CMTS1) Accelerator*
 - VI-3 *Proton Improvement Plan II Integration Test (PIP2IT) Accelerator*
 - VI-4 *Vertical Test Stand (VTS) Accelerator*
 - SAD Appendix A – Accelerator Safety Envelopes
 - VII-A.3 *Accelerator Safety Envelope – CMTS1 Accelerator*
 - VII-A.4 *Accelerator Safety Envelope – PIP2IT Accelerator*
 - VII-A.5 *Accelerator Safety Envelope – VTS Accelerator*
- ARR #3
 - DOE O 420.2D Required Elements
 - Safety Assessment Document (SAD)
 - Accelerator Safety Envelope (ASE)
 - Clearly Defined Roles & Responsibilities
 - Listing of Accelerators and Exemptions/Equivalencies
 - USI Program
 - ARR Process
 - Contractor Assurance System (CAS)
 - Internal Assessment Process
 - Configuration Management Program
 - Readiness of People, Processes, and Equipment
 - People
 - Training & Qualifications
 - Roles & Responsibilities
 - Processes and Documentation
 - SAD Chapters reviewed in IRR #3
 - ASEs reviewed in IRR #3
 - Accelerator Operations Related Procedures
 - USI Process
 - Configuration Management
 - CAS
 - Shielding Assessments
 - ODH Analysis
 - Equipment
 - Beamline Equipment
 - Credited Controls

Future Reviews

Additional reviews, either IRRs or ARRs, will be scheduled in the future for the following areas and/or activities. These reviews are beyond the scope of the “Phased Operations Under DOE O 420.2D” implementation plan, and the schedule of these reviews is not yet determined, but are included here for awareness.

- Non-Operational Facilities
 - SAD Section III – Fermilab Main Accelerator – Accelerator Segments
 - III-11 *Tevatron*
 - III-15 *Proton*
 - SAD Section IV – Fermilab Main Accelerator – Experimental Areas and Detectors
 - IV-1 *CDF Detector*
 - IV-2 *DZero Detector*
 - IV-8 *Muon g-2 Storage Ring*
- FAST Proton Source
- NM Operations with Ammonia Target
- Spoke Test Cavity (STC) Test Stand Accelerator
- Horizontal Test Stand 2 (HTS2) Test Stand Accelerator
- MTA Secondary Beamline

References

- [1] Memo “Approval of Unreviewed Safety Issue Determinations for the Continued Operations of the Cryomodule Test Stand 1, Proton Improvement Plan II Integration Test Facility, Vertical Test Stand, and Fermilab Accelerator Science and Technology Accelerator Under Department of Energy Order 420.2c, Safety of Accelerator Facilities”. Dated November 6, 2023.
- [2] 20231009 USID form for FAST Continued Operations During 420.2D Implementation - MS-MQ-MEC rs
- [3] 20231009 USID form for Continued Operations of Test Stand Accelerators During DOE O 420.2D Implementation - MS-MQ-MEC rs
- [4] “2023_Nov – IRR #1a – Common, Support, Linac & MTA” ARR Determination Form
- [5] “2024_Jan – IRR #1b – Booster, 8 GeV, BNB+experiments, MI, RR, NuMI+experiments” ARR Determination Form
- [6] “2024_Jan – IRR #1c – Muon Campus, SwitchYard+experiments” ARR Determination Form
- [7] “2024_Jan – IRR #1d – Neutrino Muon+experiments” ARR Determination Form
- [8] “ARR Determination Form_V2_NM Restart E1039 #1 – 20221020 – approved – OBSOLETE” ARR Determination Form
- [9] “ARR Determination Form_V2_E1039 #2 Ammonia Target – 20221020 – approved – OBSOLETE” ARR Determination Form
- [10] “2024_Feb – ARR #1 – Fermilab Main Accelerator” ARR Determination Form
- [11] “2024_Jan – IRR #2 – FAST” ARR Determination Form
- [12] “2024_Feb – ARR #2 – FAST Accelerator” ARR Determination Form
- [13] “2024_Feb – IRR #3 – Test Stand Accelerators (CMTS1, PIP2IT, VTS)” ARR Determination Form
- [14] “2024_Feb – ARR #3 – Test Stand Accelerators (CMTS1, PIP2IT, VTS)” ARR Determination Form