APPLIED PHYSICS & SUPERCONDUCTING TECHNOLOGY FACILITIES

SECTION II CHAPTER 05

OF THE FERMILAB SAD

Revision 1 August 9, 2023

This Chapter of the Fermilab Safety Assessment Document (SAD) contains a summary of the results of the Safety Analysis for the Applied Physics & Superconducting Technology facilities that are pertinent to understanding the risks to the workers, the public, and the environment due to its operation.

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SAD Chapter Review

This Section II, Chapter 5 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD), *Applied Physics & Superconducting Technology Facilities*, was prepared and reviewed by the staff of the Applied Physics & Superconducting Technology Directorate (APS-TD), in conjunction with the Environment, Safety & Health Division (ESH) Accelerator Safety Department.

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

☐ ______________________ Line Organization Owner

☐ Madelyn Schoell ______________________ Accelerator Safety Department Head

☐ Madelyn Schoell ______________________ SAD Review Subcommittee Chair

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Revision History

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

Author	Rev. No.	Date	Description of Change
Jamie Blowers	1	August 9, 2023	• Update to align with updated SAD Layout • Incorporation of Risk Matrix tables and hazard discussion • Updated title to match Organizational change
Rick Ruthe	0	June 1, 2015	Initial release of the Technical Division Facilities chapter of the Fermilab Safety Assessment Document

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Table of Contents

Acronyms and Abbreviations

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

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

HLCF	High Level Calibration Facility
HPR	Highly Protected Risk
Hr	Hour
HRA	High Radiation Area
HSSD	High Sensitivity Air Sampling Detection
HVAC	Heating, Ventilation, and Air Conditioning
HWSF	Hazardous Waste Storage Facility
Hz	Hertz
IB	Industrial Building
IBC	International Building Code
ICW	Industrial Cooling Water
IEPA	Illinois Environmental Protection Agency
IEEE	Institute of Electrical and Electronics Engineers
INFN	Istituto Nazionale di Fisica Nucleare
IMPACT	Integrated Management Planning and Control Tool
IPCB	Illinois Pollution Control Board
IQA	Integrated Quality Assurance
ISD	Infrastructure Services Division
ISM	Integrated Safety Management
ITNA	Individual Training Needs Assessment
KeV	kilo-electron volt
kg	kilo-grams
kW	kilo-watt
LBNF	Long Baseline Neutrino Facility
LCW	Low Conductivity Water
LHC	Harge Hadron Collider
LLCF	Low Level Calibration Facility
LLWCP	Low Level Waste Certification Program
LLWHF	Low Level Waste Handling Facility
LOTO	Lockout/Tagout
LPM	Laser Profile Monitor
LSND	Liquid Scintillator Neutrino Detector
LSO	Laser Safety Officer
m	meter
mA	milli-amp
MABAS	Mutual Aid Box Alarm System
MARS	Monte Carlo Shielding Computer Code
MC	Meson Center
MC&A	Materials Control and Accountability

MCI	Maximum Credible Incident
MCR	Main Control Room
MEBT	Medium Energy Beam Transport
MEI	Maximally Exposed Individual
MeV	Mega-electron volt
MI	Main Injector
MINOS	Main Injector Neutrino Oscillation Search
MMR	Material Move Request
MOI	Maximally-Exposed Offsite Individual *(Note: due to the Fermilab Batavia Site being open to the public, the location of the MOI is taken to be the location closest to the accelerator that is accessible to members of the public.)*
MP	Meson Polarized
mrad	milli-radian
mrem	milli-rem
mrem/hr	milli-rem per hour
MT	Meson Test
MTA	400 MeV Test Area
MTF	Magnet Test Facility
NASH	Non-Accelerator Specific Hazard
^{22}Na	Sodium-22
NC	Neutrino Center
NE	Neutrino East
NEC	National Electrical Code
NEPA	National Environmental Policy Act
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NM	Neutrino Muon
NMR	Nuclear Material Representative
NOvA	Neutrino Off-axis Electron Neutrino (ve) Appearance
NPH	Natural Phenomena Hazard
NRTL	Nationally Recognized Testing Laboratory
NIF	Neutron Irradiation Facility
NTSB	Neutrino Target Service Building, see also TSB
NuMI	Neutrinos at the Main Injector
NW	Neutrino West
ODH	Oxygen Deficiency Hazard
ORC	Operational Readiness Clearance
OSHA	Occupational Safety and Health Administration
pCi	pico-Curie

pCi/mL	pico-Curie per milliliter
PE	Professional Engineer
PIN	Personal Identification Number
PIP	Proton Improvement Plan
PIP-II	Proton Improvement Plan - II
PHAR	Preliminary Hazards Analysis Report
PPD	Particle Physics Directorate
PPE	Personnel Protective Equipment
QA	Quality Assurance
QAM	Quality Assurance Manual
RA	Radiation Area
RAF	Radionuclide Analysis Facility
RAW	Radioactive Water
RCT	Radiological Control Technician
RF	Radio-Frequency
RFQ	Radio-Frequency Quadrupole
RIL	RFQ Injector Line
RMA	Radioactive Material Area
RMS	Root Mean Square
RPCF	Radiation Physics Calibration Facility
RPE	Radiation Physics Engineering Department
RPO	Radiation Physics Operations Department
RRM	Repetition Rate Monitor
RSI	Reviewed Safety Issue
RSIS	Radiation Safety Interlock System
RSO	Radiation Safety Officer
RWP	Radiological Work Permit
SA	Shielding Assessment
SAA	Satellite Accumulation Areas
SAD	Safety Assessment Document
SCF	Standard Cubic Feet
SCFH	Standard Cubic Feet per Hour
SEWS	Site-Wide Emergency Warning System
SNS	Spallation Neutron Source
SR	Survey Riser
SRF	Superconducting Radio-Frequency
SRSO	Senior Radiation Safety Officer
SSB	Switchyard Service Building
SSP	Site Security Plan

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

II-5. Applied Physics & Superconducting Technology Directorate Facilities

II-5.1. Introduction

This Section II, Chapter 5 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD) covers the Applied Physics & Superconducting Technology (APS-TD) facilities. Note that this chapter does not include the Superconducting Radio Frequency (SRF) Vertical Test Stand (VTS) in Industrial Building 1, as that system is now considered an accelerator within the scope of the Accelerator Safety DOE Order 402.2D, and so it has its own SAD chapter and ASE.

II-5.1.1 Purpose/Function

The primary mission of APS-TD is to pursue highly-innovative R&D in superconducting magnets and SRF for accelerators and quantum technology, in order to advance the lab's scientific mission and to help in defining the lab's future direction. In order to accomplish this APS-TD operators a number of non-accelerator facilities.

II-5.1.2 Current Status

The Applied Physics & Superconducting Technology facilities are currently: **Operational**.

II-5.1.3 Description

APS-TD operates world-class facilities used to pursue R&D in superconducting materials, magnets, and cavities, as well as assembly and testing of conventional and superconducting magnets and SRF cavities and cryomodules. In support of this APS-TD also operates fabrication and inspection facilities, as well as storage buildings. In addition, APS-TD houses quantum computing facilities which are operated by the Superconducting Quantum Materials and Systems Center (SQMS).

The facilities include:

- Superconducting cabling and testing (reaction ovens, strand test stands, cable fabrication)
- Conventional and superconducting coil fabrication (winding, curing, reacting, impregnation, including laser cutting equipment)
- Conventional and superconducting magnet fabrication (core stacking, magnet coil/core structure assembly, welding presses, coldmass and cryoassembly)
- Conventional and superconducting magnet operational performance testing
- Superconducting RF cavity processing (high pressure rinsing, chemical and mechanical surface polishing), assembly (cleanroom), and testing
- SRF cryomodule assembly
- Material analysis and testing (e.g. Instron, SEM, EDS, EBSD, optical laser confocal microscopy, chemical treatment of test samples)
- Cryogenic facilities in support of the R&D and test stands (including 4K liquid Helium, 2K superfluid Helium, and mK cryogenic systems)

- Machining and Fabrication (manual and numerically-controlled lathes and mills, wire EDM, water jet and manual cutting, manual and automated welding)
- Inspection facilities and equipment (CMMs, optical comparators, laser tracker, XRF material analysis, electrical testing, hydrostatic and water flow testing)
- Dilution refrigerator quantum computing lab
- Storage facilities for components and completed assemblies

II-5.1.4 Location

The APS-TD facilities are located on the Fermilab site in Batavia, IL.

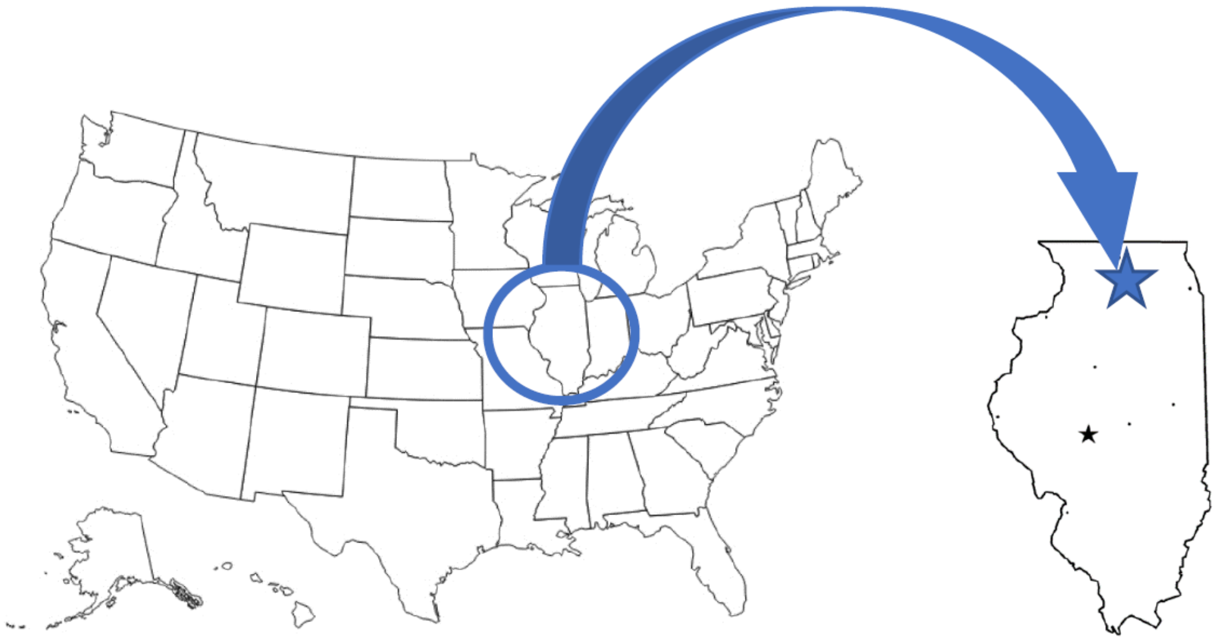

Figure 1. Regional view showing the location of the Fermilab site in Batavia, IL.

The APS-TD facilities are located in the so-called “Industrial Area” and “Village”, as well as along or near the fixed target beamlines (experimental enclosures converted into storage) on the Fermilab site.

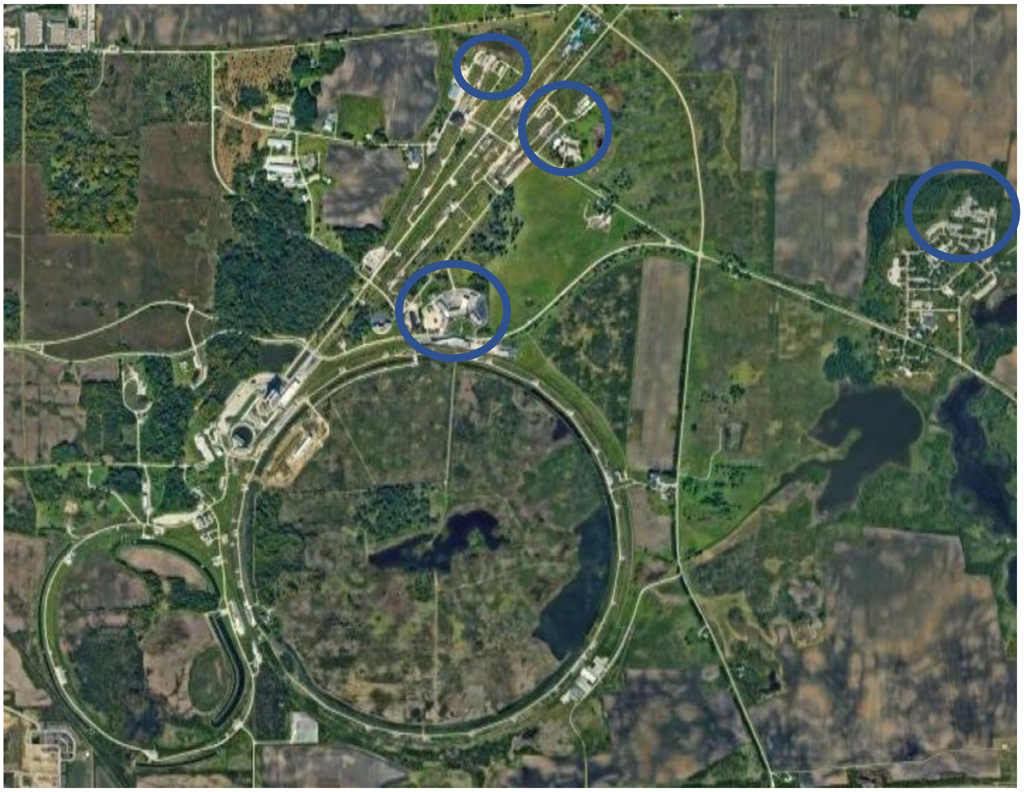

Figure 2. Aerial view of the Fermilab site, indicating the location of the APS-TD facilities.

	This area includes:
	• Industrial Buildings (#'s 1 through 4, plus Center, and additions to #'s 2, 3, and Center)
	  ○ Coil, magnet, cryomodule assembly
	  ○ Cavity processing facilities (chemistry, heat treatment, welding)
	  ○ Cavity, and conventional and SC magnet testing facilities
	  ○ Material R&D and inspection facilities
	  ○ Quantum computing labs
	• Heavy Assembly Building
	  ○ Mu2e solenoid assembly
	  ○ Quantum computing facility

<table>
<tr><td></td><td>This area in the “Village” includes:
Lab 1, Lab 4, and Machine Repair buildings used for the Machine/Weld Shops (circled in blue)
Lab 2 used for SRF assembly work (circled in red)
Material Development Testing Lab (MDTL, circled in yellow)
Lab 8 used for material storage (circled in green)</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>This area includes:
MW9 (Cryogenic Division offices and assembly area)
MP9 (SRF cleanrooms for string assembly, and coldmass assembly)</td></tr>
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	This area includes the storage buildings: • Magnet Storage and Tagged Photon Lab (the latter being a fixed-target experimental enclosure converted into a storage facility)

Figure 3. Aerial close-up views of the APS-TD facilities.

II-5.1.5 Management Organization

APS-TD is organized into Divisions and Departments:

- Magnet Technology Division, comprised of the Magnet Systems Department and the Test & Instrumentation Department
- SRF Technology & Materials Science Division, comprised of the SRF Materials & Research Department and the SRF Systems Department
- Cryogenic Technology Division, comprised of the Cryogenic Engineering Department and the Cryogenic Operations Department
- Design, Fabrication & Metrology Division, comprised of the Quality & Materials Department and the Machine Shop

What is now the Superconducting Quantum Materials and Systems Center (SQMS) was "born" out of APS-TD, and so some of the SQMS facilities are operated within APS-TD buildings and supported by APS-TD personnel.

II-5.1.6 Operating Modes

All APS-TD facilities and buildings are operational.

II-5.1.7 Inventory of Hazards

The following table lists all of the identified hazards found in the APS-TD facilities and support buildings. Section I-1.10 *Appendix – Risk Matrices* describes the baseline risk (i.e., unmitigated risk), any preventative controls and/or mitigative controls in place to reduce the risk, and residual risk (i.e., mitigated risk) for facility worker, co-located worker and Maximally Exposed Offsite Individual (MOI) (i.e., members of the public). A summary of these controls is described within Section I-1.2 *Safety Assessment.*

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

Prompt ionizing and Oxygen Deficiency Hazards due to cryogenic systems within accelerator enclosures have been identified as accelerator specific hazards, and as such their controls are identified as Credited Controls. The only facility within APS-TD to which this applies is the cavity Vertical Test Stand (VTS), which has its own SAD chapter and ASE. Other SAD chapters will have Cryogenic Liquids identified as accelerator-specific controls because they are associated with an accelerator, but because the APS-TD facilities are not associated with an accelerator (apart from VTS, which as stated previously has its own SAD chapter and ASE), Cryogenic Liquids in APS-TD are considered to be a Standard Industrial Hazard and are handled through FESHM.

Table 1. Hazard Inventory for APS-TD.

	Radiological		**Toxic Materials**
☐	**Prompt Ionizing Radiation**	☒	Lead Shielding
☒	Residual Activation	☒	Beryllium
☐	Groundwater Activation	☒	Flourinert & Its Byproducts [for APS-TD this is HF Acid]
☐	Surface Water Activation	☐	Liquid Scintillator Oil
☐	Radioactive Water (RAW) Systems	☐	Pseudocumene
☐	Air Activation	☐	Ammonia
☐	Closed Loop Air Cooling	☒	Nanoparticle Exposures
☐	Soil Interactions		**Flammables and Combustibles**
☒	Radioactive Waste	☒	Combustible Materials (e.g., cables, wood cribbing, etc.)
☒	Contamination	☒	Flammable Materials (e.g., flammable gas, cleaning materials, etc.)
☐	Beryllium-7		**Electrical Energy**
☐	Radioactive Sources	☒	Stored Energy Exposure
☐	Nuclear Material	☒	High Voltage Exposure
☒	Radiation Generating Devices (RGDs)	☒	Low Voltage, High Current Exposure
☒	Non-Ionizing Radiation Hazards		**Kinetic Energy**
	Thermal Energy	☒	Power Tools
☒	Magnet Bakeouts	☒	Pumps and Motors
☒	Hot Work	☒	Motion Tables
☒	Cryogenic Liquids	☐	Mobile Shielding
	Potential Energy		**Magnetic Fields**
☒	Crane Operations	☒	Fringe Fields
☒	Compressed Gasses		**Other Hazards**
☒	Vacuum/Pressure Vessels	☒	Confined Spaces
☒	Vacuum Pumps	☒	Noise
☒	Material Handling	☒	Silica
	Access & Egress	☒	Ergonomics
☐	Life Safety Egress	☐	Asbestos

II-5.2. Safety Assessment

All hazards for the APS-TD facilities are summarized in this section, with additional details of the analyses for accelerator specific hazards.

II-5.2.1 Radiological Hazards

The work in APS-TD includes radiological hazards in the form of residual activation, radioactive waste, contamination, RGDs, and non-ionizing radiation.

The radiological hazards baseline risk was assessed as a risk level I. After consideration of control measures in place, the residual risk level is evaluated as a risk level R IV.

II-5.2.1.1 Prompt Ionizing Radiation

Not applicable in APS-TD.

II-5.2.1.2 Residual Activation

Devices which have been used in an accelerator are assembled, repaired, and tested in APS-TD. These devices may have residual activation and are handled through the controls defined in the FRCM. Through surveys and standard radiological work practices, training, and work planning and control procedures the risk from tis hazard is mitigated.

II-5.2.1.3 Groundwater Activation

Not applicable in APS-TD.

II-5.2.1.4 Surface Water Activation

Not applicable in APS-TD.

II-5.2.1.5 Radioactive Water (RAW) Systems

Not applicable in APS-TD.

II-5.2.1.6 Air Activation

Not applicable in APS-TD.

II-5.2.1.7 Closed Loop Air Cooling

Not applicable in APS-TD.

II-5.2.1.8 Soil Interactions

Not applicable in APS-TD.

II-5.2.1.9 Radioactive Waste

Radioactive waste produced in the course of APS-TD operations is managed within the established Radiological Protection Program (RPP) and as prescribed in the Fermilab Radiological Control Manual (FRCM).

Radioactive waste is a standard radiological hazard that is managed within the established Radiological Protection Program (RPP) and as prescribed in the Fermilab Radiological Control Manual (FRCM). Waste minimization is an objective of the equipment design and operational procedures. and so reuse of activated items will be carried out when feasible. Activated items that cannot be reused are disposed of as radioactive waste in accordance with the FRCM requirements.

II-5.2.1.10 Contamination

Devices which have been used in an accelerator are assembled, repaired, and tested in APS-TD. These devices may have residual activation which could result in contamination, and they are handled through the controls defined in the FRCM.

II-5.2.1.11 Beryllium-7

Not applicable in APS-TD.

II-5.2.1.12 Radioactive Sources

Not applicable in APS-TD.

II-5.2.1.13 Nuclear Material

Not applicable in APS-TD.

II-5.2.1.14 Radiation Generating Devices (RGDs)

APS-TD operates two RDGs: SEM and an XRF Alloy Analyzer. Both are operated within the controls defined in the FRCM. The use of RWPs, worker training, equipment construction and operational plans for RGDs contribute to reducing risks poses by RGDs.

II-5.2.1.15 Non-Ionizing Radiation Hazards

APS-TD has non-ionizing radiation hazards in the form of lasers, and UV and RF sources. The class 2 (and lower) lasers pose no measurable risk, and the class 3B and 4 lasers are operated per the requirement defined in FESHM. The UV and RF sources (RF that is NOT associated with VTS) are of sufficiently low power that they pose no measurement risk.

II-5.2.2 Toxic Materials

The work in APS-TD includes toxic materials hazards in the form of lead, Beryllium, Hydrofluoric Acid, and nanoparticle exposure. A detailed assessment addresses these hazards and provides a detailed analysis of the facility demonstrating the required controls to comply with the Fermilab Environment, Safety, & Health Manual (FESHM).

The toxic materials hazard baseline risk was assessed as a risk level I. After consideration of control measures in place, the residual risk level is evaluated as a risk levels R III or IV.

II-5.2.2.1 Lead

Lead in APS-TD is in the form of enclosed lead blankets (used extremely infrequently to shield a highly-radioactive magnet which it’s being worked on), lead-based solder, and the infrequent device which has lead-based paint. All hazards are being managed per FESHM requirements and are considered well-managed.

II-5.2.2.2 Beryllium

All Beryllium alloy components used in APS-TD are "articles", and are never machined or welded, and so pose no risk of airborne dust. Nonetheless all workers which handle Beryllium receive training on proper handling.

II-5.2.2.3 Fluorinert & Its Byproducts

Fluorinert is not used with APS-TD, however Hydrofluoric (HF) acid is. All operations involving HF are tightly controlled, and required an extensive amount of planning, documenting, reviewing, and authorizing to begin working with HF. All work is performed to SOPs, using trained and qualified personnel with the necessary PPE. In addition, the amount of HF acid in use is limited. The overall result is low residual risk.

II-5.2.2.4 Liquid Scintillator Oil

Not applicable in APS-TD.

II-5.2.2.5 Pseudocumene

Not applicable in APS-TD.

II-5.2.2.6 Ammonia

Not applicable in APS-TD.

II-5.2.2.7 Nanoparticle Exposures

Nanoparticle use in APS-TD comes from their use as abrasives in treating surfaces of materials. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.3 Flammables and Combustibles

Work in APS-TD involve both flammable and combustible materials.

II-5.2.3.1 Combustible Materials

Combustible materials are minimized through regular housekeeping and area inspections, and all facilities have smoke detectors and fire suppression systems.

II-5.2.3.2 Flammable Materials

Flammable materials are minimized through regular housekeeping and area inspections, which includes ensuring proper storage. In addition all facilities have smoke detectors and fire suppression systems.

II-5.2.4 Electrical Energy

The work performed in APS-TD includes electrical energy hazards stemming from infrastructure, testing equipment (e.g. test stand power supplies, hipoters), and energized devices (e.g. magnets during testing). This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.4.1 Stored Energy Exposure

Stored energy hazards come from energized testing equipment and energized devices. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.4.2 High Voltage Exposure

High voltage exposure hazards come from infrastructure, testing equipment, and energized devices. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.4.3 Low Voltage, High Current Exposure

Low voltage, high current exposure hazards come from infrastructure, testing equipment, and energized devices. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.5 Thermal Energy

The work in APS-TD includes thermal energy hazards in the form of bakeouts, hot work, and cryogenics. A detailed assessment addresses these hazards and provides a detailed analysis of the facility demonstrating the required controls to comply with the Fermilab Environment, Safety, & Health Manual (FESHM).

The thermal energy hazards baseline risk was assessed as a risk level I. After consideration of control measures in place, the residual risk level is evaluated as a risk level R IV.

II-5.2.5.1 Bakeouts

Bakeouts in APS-TD are performed on single magnets (e.g. Lambertsons), using heaters, power supplies, and insulating materials. The work is performed using SOPs, using equipment approved by Electrical Safety, and the area is roped off and signed “Do Not Enter”. The result is minimal residual risk.

II-5.2.5.2 Hot Work

In addition to the hot work performed within APS-TD, our Directorate also includes the Weld Shop, and so our staff (i.e. welders) perform hot work across the site. All hot work requires a Hot Work Permit, which is issued by the onsite Fire Department. In addition, all welders wear PPE (e.g. to protect from burns and UV), and welding is performed in well-ventilated areas, sometimes using fume extractors to remove fumes which can include Hexavalent Chromium (when welding Stainless Steel). The result is minimal residual risk.

II-5.2.5.3 Cryogenics

In addition to the cryogenic work performed within APS-TD, our Directorate also includes the Cryogenic Division at Fermilab. All cryogenic systems are designed and fabricated according to the ASME BPVC, or purchased commercially (e.g. dewars). All systems require an ORC before being operated. The handling of cryogens requires formal training and PPE. The result is minimal residual risk.

II-5.2.6 Kinetic Energy

The work performed in APS-TD includes kinetic energy hazards stemming from power tools, pumps & motors, and motion tables. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.6.1 Power Tools

Various power hand tools and machine tools (e.g. pipe cutters, mills, lathes) are used throughout APS-TD. This includes the Machine Shop Department at the lab. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.6.2 Pumps and Motors

Various pumps and motors are used in the assembly of magnet assemblies. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.6.3 Motion Tables

Motion tables are used in APS-TD for the assembly and testing of coils and magnets (e.g. coil winding table/tooling). This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.6.4 Mobile Shielding

Not applicable in APS-TD.

II-5.2.7 Potential Energy

The work in APS-TD includes potential energy hazards in the form of crane operations, compressed gasses, vacuum/pressure vessels, vacuum pumps, and material handling. A detailed assessment addresses these hazards and provides a detailed analysis of the facility demonstrating the required controls to comply with the Fermilab Environment, Safety, & Health Manual (FESHM).

II-5.2.7.1 Crane Operations

Overhead cranes are used extensively throughout APS-TD facilities. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.7.2 Compressed Gasses

Compressed gasses are used throughout APS-TD. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.7.3 Vacuum/Pressure Vessels

Vacuum/pressure vessels are fabricated and used in APS-TD. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.7.4 Vacuum Pumps

Vacuum pumps are used throughout APS-TD. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.7.5 Material Handling

Materials are moved throughout APS-TD by various means (e.g. vehicles, forklift trucks, pallet jacks, by hand). This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.8 Magnetic Fields

APS-TD designs, builds, and tests permanent and electromagnets, conventional and superconducting, both for in-house use as well as for other laboratories in the US and around the world. Magnets range in size from a few hundred pounds to 10’s of tons. In addition, permanent magnets are used in some of the equipment (e.g. ion pumps).

The magnetic field hazard baseline risk was assessed as a risk level I. After consideration of control measures in place, the residual risk level is evaluated as a risk levels R III and IV.

II-5.2.8.1 Fringe Fields

Although very strong fringe fields can affect some people, the highest concern is the effect of the fields on individuals with implanted medical devices. APS-TD is very active regarding identifying when work could include large fringe fields, and planning accordingly. In those cases we work with IH to perform surveys and mark areas where the 5G boundary is. Then we rely on individuals who may be affected to either not proceed past the marked roping, or to self-identify, in which case they would receive additional information regarding how to protect themselves from the hazards of fringe fields.

II-5.2.9 Other Hazards

The work in APS-TD includes other hazards in the form of confined spaces, noise, silica, ergonomics, and working at heights. A detailed assessment addresses these hazards and provides a detailed analysis of the facility demonstrating the required controls to comply with the Fermilab Environment, Safety, & Health Manual (FESHM).

II-5.2.9.1 Confined Spaces

APS-TD operates a number of ovens of varying sizes. Some of them are large enough that they present a confined space hazard when they require maintenance. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.9.2 Noise

Equipment used in APS-TD, both facility infrastructure (e.g. air handling systems) and that used to fabricate or assemble devices (e.g. water jet cutting), present noise hazards. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.9.3 Silica

In addition to airborne exposure from work with concrete or moving gravel related to construction activities, APS-TD does use a very small amount of fumed silica in the making of small batches of epoxy for magnet repairs. Silica hazards associated with concrete work or other construction activities are handled through proper work planning, training, and PPE. N95 masks are worn while mixing fumed silica into epoxy.

The abrasives used in the water jet cutting machines (Machine Shop) and the grit blast booth (IB2) are garnet and aluminum oxide, respectively, neither of which contain silica.

II-5.2.9.4 Ergonomics

Ergonomics is always a concern for hands-on and computer-based work. This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.9.5 Asbestos

Not applicable in APS-TD.

II-5.2.9.6 Working at Heights

This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.10 Access & Egress

Not applicable in APS-TD.

II-5.2.10.1 Life Safety Egress

Not applicable in APS-TD.

II-5.2.11 Environmental

The work in APS-TD includes environmental hazards in the form of **chemical** releases beyond permitted limits into the air, water, and soil. A detailed assessment addresses these hazards and provides a detailed analysis of the facility demonstrating the required controls to comply with the Fermilab Environment, Safety, & Health Manual (FESHM).

II-5.2.11.1 Hazard to Air

This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.11.2 Hazard to Water

This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.2.11.3 Hazard to Soil

This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 Safety Analysis. Work in APS-TD involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

II-5.3. Summary of Hazards to Members of the Public

The public cannot access the inside areas of APS-TD facilities, and so the work in those areas poses no risk to the public. In a few instances work can be performed outside (e.g. construction, welding/torch cutting, material moves, XRF alloy analyzer of material too large/heavy to move), but that is done in areas which are off limits to the public. If, for some reason, a member of the public wanders into those areas while work is being performed, the work will stop and the individual will be escorted back to a public space (via Security, who will also deal with how and why the individual was in a non-public area).

II-5.4. Summary of Credited Controls

APS-TD non-accelerator facilities have no credited controls.

II-5.4.1 Passive Credited Controls

N/A

II-5.4.1.1 Shielding

N/A

II-5.4.1.1.1 Permanent Shielding Including Labyrinths

N/A

II-5.4.1.1.2 Movable Shielding

N/A

II-5.4.1.1.3 Penetration Shielding

N/A

II-5.4.1.2 Fencing

N/A

II-5.4.1.2.1 Radiation Area Fencing

N/A

II-5.4.1.2.2 Controlled Area Fencing

N/A

II-5.4.2 Active Engineered Credited Controls

N/A

II-5.4.2.1 Radiation Safety Interlock System

N/A

II-5.4.2.2 ODH System

N/A

II-5.4.3 Administrative Credited Controls

N/A

II-5.4.3.1 Operation Authorization Document

N/A

II-5.4.3.2 Staffing

N/A

II-5.4.3.3 Accelerator Operating Parameters

N/A

II-5.5. Defense-in-Depth Controls

N/A

II-5.6. Machine Protection Controls

N/A

II-5.7. Decommissioning

N/A

II-5.8. Summary and Conclusion

The non-accelerator operations in APS-TD have been identified and thoroughly assessed, identifying specific hazards, their current controls, and any residual risks. Many hazards are managed as Standard Industrial Hazards, while some have been described and documented in the Safety Assessment Document in a manner which is specific to APS-TD. In all cases the controls are implemented following the requirements defined in the Fermilab Environment, Health, and Safety Manual (FESHM) and the Fermilab Radiation Control Manual (FRCM). The conclusion is APS-TD facilities are operated with a level of safety that is protecting people (onsite and offsite) and property, with minimal residual risks.

II-5.9. References

[1] Fermilab Radiological Control Manual

II-5.10. Appendix – Risk Matrices

Risk Assessment methodology was developed based on the methodology described in DOE-HDBK-1163-2020. Hazards and their potential events are evaluated for likelihood and potential consequence assuming no controls in place, which results in a baseline risk. A baseline risk (i.e., an unmitigated risk) value of III and IV does not require further controls based on the Handbook. Events with a baseline risk value of I or II do require prevention and/or mitigation measures to be established in order to reduce the risk value to an acceptable level of III or IV. Generally, preventive controls are applied prior to a loss event, reflecting a likelihood reduction, and mitigative controls are applied after a loss event, reflecting a consequence reduction. For each control put in place, likelihood or consequence can have a single “bin drop”, resulting in a new residual risk (i.e., a mitigated risk). This risk assessment process is repeated for each hazard for Facility Workers (FW), Co-Located Workers (CLW), and Maximally-Exposed Offsite Individual (MOI). At the conclusion of the risk assessments, controls that are in place for the identified accelerator specific hazards are identified as Credited Controls and further summarized in Section I-1.4 of this Chapter.