Revision 0

Jefferson Lab

THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY VERTICAL TEST AREA ACCELERATOR SAFETY ENVELOPE

April 2025

U.S. DEPARTMENT OF ENERGY

JSA

Prepared for the U.S. Department of Energy under Contract DE-AC05-06OR23177

Approval Page
for the
Thomas Jefferson National Accelerator Facility
Vertical Test Area (VTA) Accelerator Safety Envelope
Revision 0

Jefferson Lab Director

Print _____ **Date** _____

Kimberly Sawyer

Associate Director,
Accelerator Operations,
Research and Development
Division

Print _____ **Date** _____

Andrei Seryi

Director,
Environment, Safety, and Health

Print _____ **Date** _____

Paul Gubanc

Director,
Facilities Management
and Logistics

Print _____ **Date** _____

Kent Hammack

Manager,
Engineering Division

Print _____ **Date** _____

Tim Michalski

Manager,
SRF Operations

Print _____ **Date** _____

Tony Reilly

DOCUMENT REVISIONS

Approvals

All revisions to this document require approval from the Thomas Jefferson Site Office (TJSO).

Major revisions require approval, on a new signature page. These include the Laboratory Director, the Associate Directors of Accelerator and Environment, Safety, and Health (ES&H), and the Department managers of SRF Operations, Engineering, and Facilities Management and Logistics (FM&L). Major revisions require a full number change incremented appropriately (i.e. Rev 2.1 becomes Rev 3; Rev 3 becomes Rev 4; etc.) and a notation within the Revision Summary.

Interim revisions incorporating minor changes such as clarifications, minor corrections that do not change the intent of the document, and typographical corrections require Jefferson Lab approval by the Associate Director(s) of the affected division(s) and Associate Director, ES&H Division. Minor revisions are denoted by a mantissa (fractional number) incremented as appropriate (i.e. Rev 0 becomes Rev 0.1; Rev 1.2 becomes Rev 1.3, etc.), and a notation is made within the Revision Summary.

Revision Summary

Rev.	Reason for Revision	Approval	Date
0	Initial issue.	See signature page	4/2025

TABLE OF CONTENTS

1.0 INTRODUCTION

The *Department of Energy (DOE) Order 420.2D Safety of Accelerators* establishes accelerator-specific safety requirements and approval authorities. The DOE O 420.2D requires Thomas Jefferson National Accelerator Facility (Jefferson Lab) to conduct a hazard analysis for accelerator-specific safety risks and identify the controls necessary to mitigate those risks. The accelerator-specific hazard analysis and necessary controls associated with the operation of the Vertical Test Area (VTA) are provided in the *Jefferson Lab Safety Assessment Document* (SAD) Revision 9a. The set of accelerator-specific controls identified in the safety analysis that are essential for safe accelerator operations are referred to as Credited Controls. These Credited Controls collectively form the bounding conditions for the *Accelerator Safety Envelope* (ASE).

The ASE is approved by the Thomas Jefferson Site Office (TJSO) and is contractually binding for the operation of the Jefferson Lab accelerators referenced herein.

2.0 FACILITY DESCRIPTION

The Vertical Test Area (VTA) is located on the first floor Test Lab along the East wall of the High Bay Area (Building 58; Room 1116). The Cryomodule Test Facility (CMTF) and VTA are built on the repurposed site of the NASA Space Radiation Effects Laboratory 600 MeV Synchrocyclotron. The facility includes the testing area (Dewar Area; Room 1116), two control rooms along its south wall (Rooms 1114-1115), and a Vertical Staging Area (VSA) with a cleaned/unclassified clean room (Rooms 1117-2117). There are eight test dewars in the VTA, six of which (i.e. dewar numbers 3 through 8) are used for high power RF (HPRF) tests and the other two (i.e. dewar numbers 1 and 2) are used for cryogenic tests that are incapable of generating prompt ionizing radiation. Any operations performed in the two unshielded dewars are cryogenic in nature and do not involve the application of RF. The dewars benefit from the operational discipline of the VTA but cannot make a Radiation Area and do not meet the definition of an accelerator or accelerator operations. Consequently, dewar numbers 1 and 2 do not require (and have no) credited controls and their operation is not governed by this ASE.

Each of the six cavity test enclosures have separate shielding, which enables test preparations in one cryostat while another is in active use. When the shielding lid is closed, a five-sided enclosure surrounds the top of the dewar and extends two and a half feet below the floor. Each side of the enclosure is constructed with at least 8 inches of solid lead bricks.

Access to the test area is through one of two entry points, a sliding metal gate door, or entering through either control room door. This access is restricted for radiological monitoring purposes. The sliding metal gate door on the south wall will be the primary access and egress used for transferring test cavities between the Vertical Assembly Area (VAA) and the VSA to be prepared for Dewar testing. The VTA Dewar area access doors inside each control room are used for primary access and egress for preparing the designated enclosure for testing. Once the PSS interlock system is armed, both the sliding metal gate door and VTA control room access doors are locked and both Dewar area access doors inside the VTA control room are posted for Radiation Area access. Access during High Power RF testing is controlled using the Central Alarm Notification System (CANS) and managed by the VTA Facility Manager. Personnel entering the VTA shall comply with all requirements of the VTA Radiation Work Permit (RWP) to monitor and limit their exposure to ionizing radiation.

The VTA is primarily an acceptance testing facility for individual vertically oriented SRF cavities. Once eight cavities are approved, individual cryostats are packaged and assembled into cryomodules, which serve as beam accelerating devices at CEBAF and other accelerators and facilities throughout the world.

3.0 ACCELERATOR SAFETY ENVELOPE (ASE) VIOLATION

Operation of the VTA without the specified credited controls in place and functional is a violation of the ASE. If a Credited Control is inoperable or ineffective, compensatory measures may be used. Acceptable compensatory measures are listed with each Credited Control. Other compensatory measures may be used if those measures are evaluated by the Safety Configuration Management Board (SCMB) and approved by the TJSO. When an ASE violation occurs, RF Operations in the VTA shall cease and not resume until:

- The situation is investigated and documented in accordance with the Critical Event Response section of the *VTA Operations Directives (VOD)* and *ES&H Manual Chapter 5200*, the cause(s) identified, corrective actions or approved compensatory measures implemented, and,
- Formal notification is made to TJSO documenting the cause of the occurrence, corrective actions and the intention to restart accelerator operations.

If a Credited Control proves to be inoperative or ineffective, RF operations shall stop until the actions specified above are taken.

If an ASE violation is identified by TJSO and VTA RF Operations are stopped at TJSO's request, operations shall not resume until approved by TJSO.

A violation of the ASE is typically very clear. However, there may be minor failures of controls that are less obvious but still constitute a violation of the ASE. There may also be situations where a Credited Control is potentially ineffective but the identified compensatory measures are in place. Determining whether a condition is a violation or a (less severe) safety concern can be subjective. The following are examples of potential ASE violations these are intended to serve as guidance to facilitate such determinations. Judgment may be necessary to evaluate specific situations and a list below is not comprehensive:

- Surveillance of Credited Controls in an accelerator in operation not conducted in the time-frame specified in the Management and Surveillance description for that Credited Control.
- Movable shielding identified as a Credited Control is not in place during operation of the accelerator.
- Both independent Personnel Safety System (PSS) channels for the same Credited Control are inoperable during operation of the accelerator.
- Accelerator operation without completing the required review process: a successful Accelerator Readiness Review with authorization to run granted by the TJNAF DOE Site Office, along with the Head of SRF Operations.
- Operation of the accelerator with less than the minimum specified qualified staff in the VTA Control Room.

The SCMB, chartered by the Jefferson Lab Director, evaluates safety concerns and determines if they represent an ASE violation and/or an Un-reviewed Safety Issue (USI). A USI is a condition that may

require an update to an existing hazards analysis in the SAD or may require the addition of a new SAD hazard along with new Credited Controls. The SCMB membership incorporates a TJSO Observer as an ex-officio member.

4.0 CREDITED CONTROLS

Credited Controls mitigate hazards that pose unacceptable risk and reduce that risk to acceptable levels. The Credited Controls, identified in the SAD, are listed below. These Credited Controls must be in place and functional when required by the state of accelerator operations.

The ASE also specifies the management and surveillance practices that must be performed to assure the continued effectiveness of the Credited Controls. Management and surveillance practices are part of an approved configuration management process that helps ensure that the physical configuration and functionality of Credited Controls remain accurate and in accordance with the analysis and requirements in the SAD. Management and surveillance practices may have a specified frequency. Occasionally, it becomes apparent that a management and surveillance interval for a Credited Control may expire during a period when an accelerator is either scheduled for operation or is operational. Prior to the expiration of the management and surveillance interval, the interval may be extended based on the results of evaluation by the SCMB and approval by TJSO. A management and surveillance interval that expires during accelerator operation should be evaluated by the SCMB as a safety concern that represents a USI or a potential ASE violation. If a required management and surveillance interval exceeds one year the due date for the next required management and surveillance verification will be listed on the current operational authorization.

The same configuration management process is applied to temporary changes during maintenance to ensure the integrity and performance of Credited Controls are restored before accelerator operation. Configuration control is accomplished by the *Labeling Procedure for PSS and ODH Equipment*, Radiation Control Department (RCD) Procedures, the SCMB, and in accordance with the relevant Quality Assurance Program Procedures/Processes. For example, accelerator safety is assessed as part of a five-year assessment cycle. This cycle is incorporated into the Annual Assessment Schedule.

Certain management and surveillance records, such as verification of the functionality of a Credited Control before accelerator operations, may rely on electronic records and logs. Software that supports electronic records and logs is developed and maintained in accordance with the *Site-Wide Cyber Security Program* and controlled in accordance with the *Accelerator Division Controls Software Group User Account/Usage Policy*.

Sections 4.1 – 4.3 below lists the Credited Controls applied to the VTA accelerator and follow “hierarchy of controls” principles – the controls that are most effective and least prone to failure are applied first. These are typically passive engineered controls that are physical safety features built into the accelerator design. Certain Credited Passive Engineered Controls are listed in the SAD as initial assumptions (i.e. they are assumed to be in-place and functional prior to the start of accelerator operations - the concrete accelerator enclosure, for example). Active engineered controls are used when the control requirements are more complex, interactive, or interdependent. Finally, Administrative controls, which are typically programmatic in nature or are embodied in specific processes and procedures, are used last and often in conjunction with engineered controls.

4.1. Credited Passive Engineered Controls

Credited Passive Engineered Controls such as physical design features including shielding, physical barriers, flow limiting devices, and vents.

4.1.1. Permanent Shielding

Applicability:

When high-power RF operations are possible.

Controls:

- Structural shielding, typically reinforced concrete that defines the accelerator enclosure,
- Built in shielding design feature such as penetration routing.

Management and Surveillance:

- Permanent shielding shall be subject to the *Jefferson Lab Shielding Policy for Ionizing Radiation*.
- Shielding design and changes shall be reviewed in accordance with the *ASE Violation/USI Review Process* and approved by the Radiation Control Manager (RCM) or designee.
- The Dig/Blind Penetration Permit specified in *ES&H Manual Chapter 3320 Temporary Work Permits* shall be used to manage penetrating or otherwise disturbing the structure in a way that can impact shielding effectiveness.
- Structural shielding shall be inspected as specified by FM&L and recorded in the Condition Assessment Information System (CAIS) at least every five years. The inspection results shall be communicated to the RCM.
- The RCM or designee shall evaluate all permanent shielding at least every five years against applicable design specifications and SAD requirements, and its general condition with respect to shielding effectiveness. The evaluation shall be recorded in the Jefferson Lab Authorization Manager (JAM) for the run period identified in the JAM.

Acceptable Compensatory Measures:

If RCM evaluation determines the condition of permanent shielding associated with an accelerator enclosure does not meet the requirements specified in the SAD or is otherwise unacceptable, the RCM will recommend compensatory measures (such as additional access control, installation of temporary shielding, etc.), if necessary, to maintain the performance specified in the *Jefferson Lab Shielding Policy for Ionizing Radiation* until the shielding is restored to the values specified in the SAD or the SAD is amended. The SCMB shall review and evaluate RCM recommendations using the *ASE Violation/USI Review Process*. The design, approval, and use of compensatory measures for permanent shielding shall be subject to the *Jefferson Lab Shielding Policy for Ionizing Radiation*.

4.1.2. Movable Shielding

Applicability:

Whenever high-power RF operations are possible.

Controls:

Movable shielding[1].

Management and Surveillance:

- Movable shielding shall be subject to the *Jefferson Lab Shielding Policy for Ionizing Radiation*.
- Movable shielding design and changes shall be reviewed in accordance with the ASE Violation/USI Review Process and approved by the RCM or designee.
- Movable shielding shall be visibly labeled or tagged consistent with *ENG-AD-01-001 Conduct of Engineering Manual Section 5.2.6.1 Implementing Item Identification.*
- Correct placement of movable shielding shall be verified in accordance with the *Jefferson Lab Radiation Control Department Procedures* specified in *HPP-OPS-002, Performance of Periodic Routines* and *HPP-OPS-015, Shielding Package Determination and Tracking.*
- The RCM or designee shall record the movable shielding status, along with the expiration date for the status determination, in the JAM before facility operation.

Acceptable Compensatory Measures:

Fences or barriers with informational signs or postings consistent with the hazard that prevent inadvertent access to the affected area and mitigate the radiation hazard consistent with the requirements of the *Jefferson Lab Shielding Policy for Ionizing Radiation*.

4.2. Credited Active Engineered Control

The only Active Engineered Control is the PSS. The PSS provides monitoring of the access points of the accelerator in order to keep people from RF and field emission-based radiation hazards. In combination with Passive Engineered Controls such as shielding the PSS serves to keep people away from radiation hazards.

4.2.1. PSS Access Controls

Applicability:

Whenever high-power RF operations are possible.

Controls:

The VTA PSS shall have no loss of safety function during RF operation[2].

[1] Movable shielding is considered to be discrete shielding materials or an assembly of material that can be moved and/or disassembled, and may be a Credited Control in the SAD hazard analysis.

[2] Loss of safety function is considered to be failure of both independent interlock chains.

Management and Surveillance:

- VTA PSS components shall be visibly labeled or tagged consistent with the *Labeling Procedure for PSS and ODH Equipment*.
- Interim changes to the PSS are reviewed and approved in accordance with the *PSS Configuration Management Procedure* and the *ASE Violation/USI Review Process*. PSS functional requirements are established in the *Beam Containment and Access Control Policy*.
- The VTA PSS shall be certified annually.
- The Safety Systems Group shall record the status of the VTA PSS, along with the expiration date for the status determination, in the JAM before facility operation.

4.3. Credited Administrative Controls

Credited Administrative controls include processes, limits, and conditions necessary for safe accelerator operation as described.

4.3.1. Staffing – Operations High Power RF Enabled (No HMI Permit)

Applicability:

When VTA PSS is above disabled state and no HMI permit.

Specific Controls:

Authorized VTA RF Operator in Test Lab.

Management and Surveillance:

One trained RF operator – approved by the Vertical Test Area Facility Manager – must be on-site and in the Test Lab with the PSS State in High Power RF Enabled (No HMI Permit).

4.3.2. Staffing – Operations High Power RF Enabled (HMI Permit)

Applicability:

When VTA PSS is in enabled state and has HMI permit.

Specific Controls:

Authorized VTA RF Operator in Control Room.

Management and Surveillance:

One trained RF operator – approved by the Vertical Test Area Facility Manager – must be on-site and in the control room with the PSS State in High Power RF Enabled (HMI Permit).

DOCUMENT LIST (Alphabetical Order)

Accelerator Division Controls Software Group User Account/Usage Policy
Accelerator Safety Envelope Violation/Unreviewed Safety Issue Review Process
Accelerator Safety Envelope (ASE)
Beam Containment and Access Control Policy
Conduct of Engineering Manual ENG-AD-01-001 Section 5.2.6.1 Implementing Item Identification
Department of Energy (DOE) Order 420.2D Safety of Accelerators
ES&H Manual Chapter 3320, Temporary Work Permits
ES&H Manual Chapter 5200, Unplanned Incidents
ES&H Manual Chapter 6111, Administrative Control Using Locks and Tags
Jefferson Lab Safety Assessment Document
Jefferson Lab Shielding Policy for Ionizing Radiation
Labeling Procedure for PSS and ODH Equipment
PSS Configuration Management Procedure
Radiation Control Department Procedures - HPP-OPS-002, Performance of Periodic Routines
Radiation Control Department Procedures - HPP-OPS-015, Shielding Package Determination and Tracking
Site-Wide Cyber Security Program
VTA Operations Directives (VOD)

ACRONYMS

Acronym	Definition	Page
FM&L	Facilities Management and Logistics	II
ASE	Accelerator Safety Envelope	1
CANS	Central Alarm Notification System	1
CMTF	Cryomodule Test Facility	1
DOE	Department of Energy	1
Jefferson Lab	Thomas Jefferson National Accelerator Facility	1
RWP	Radiation Work Permit	1
SAD	Safety Assessment Document	1
TJSO	Thomas Jefferson Site Office	1
VAA	Vertical Assembly Area	1
VSA	Vertical Staging Area	1
VTA	Vertical Testing Area	1
PSS	Personnel Safety System	2
SCMB	Safety Configuration Management Board	2
RCD	Radiological Control Department	3
USI	Unreviewed Safety Issue	3
CAIS	Condition Assessment Information System	4
JAM	Jefferson Lab Authorization Manager	4
ES&H	Environment, Safety, and Health	4
RCM	Radiation Control Manager	4