Jefferson Science Associates
Thomas Jefferson National Accelerator Facility

October 3, 2019

Department of Energy
Thomas Jefferson Site Office
12000 Jefferson Avenue, Suite 14
Newport News, VA 23606

ATTENTION: Joseph Arango

SUBJECT: **CONTRACT DE-AC05-06OR23177,** Transmittal of the Final Accelerator Safety Envelope (ASE) Revision 0 for Upgraded Injector Test Facility Accelerator (UITF) for approval

Reference: SAF701kd Revision 5, Final Safety Assessment Document Revision 8 (FSAD Rev 8)

Attachments: UITF ASE Revision 0 (Rev 0)

Attached for your approval is the Final UITF ASE Rev 0 intended for UITF accelerator commissioning and operation. UITF ASE Rev 0 is supported by FSAD Rev 8. Please note that FSAD Rev 8 is being updated to incorporate recommendations from the UITF ARR conducted June 26-29, 2019.

We appreciate the substantive and helpful discussions with your staff during preparation of the Final UITF ASE Rev 0 as well their continued ex-officio participation in the Safety Configuration Management Board.

Subsequent to your approval, we will conduct familiarization training for ASE Rev 0 and will notify you when it becomes the standing ASE for the planned commissioning and operation of the UITF. If you have any questions related to the UITF ASE Revision 0, don't hesitate to contact Bob May at ext.7632 or Harry Fanning at ext.7619.

Sincerely,

Stuart Henderson
Laboratory Director

cc:
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Revision 0

Jefferson Lab

Thomas Jefferson National Accelerator Facility

UPGRADED INJECTOR TEST FACILITY ACCELERATOR SAFETY ENVELOPE

October 2019

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
Upgraded Injector Test Facility
Accelerator Safety Envelope
Revision 0

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Date 10/4/19

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DOCUMENT REVISIONS

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, and Associate Directors of Physics, Accelerator, and Environment, Safety, Health, and Quality (ESH&Q). 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, ESH&Q 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	10/2019

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1.0 INTRODUCTION

The *Department of Energy (DOE) Order 420.2C Safety of Accelerator Facilities* (ASO) establishes accelerator-specific safety requirements and approval authorities. The ASO 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 operation of the Upgraded Injector Test Stand (UITF) are provided in the *Jefferson Lab Final Safety Assessment Document* (FSAD) Revision 8.a. 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 operation of the Jefferson Lab accelerators referenced herein.

2.0 FACILITY DESCRIPTION

The UITF is an upgrade to the former Injector Test Stand (ITS) located in the Test Lab High Bay (High Bay). The UITF occupies both the former ITS cave (Cave 1) and includes a second contiguous enclosure (Cave 2) that extends the former ITS further into the High Bay area.

The UITF has two principle purposes: conduct small-scale physics research experiments at low energy and serve as a research accelerator to test accelerator capability and accelerator components. For these purposes, beam can be delivered to in-line dumps and experimental apparatus in Cave 1 or 2. The requirements in this ASE apply to either mode of operation.

The UITF also serves as an electron gun test stand. Electron gun test stand operation is not accelerator operation and is not governed by this ASE.

3.0 ACCELERATOR SAFETY ENVELOPE (ASE) VIOLATION

Operation of the UITF 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, beam delivery in the affected segment shall stop and not resume until:

- The situation is investigated and documented in accordance with the Critical Event Response section of the *UITF Operations Directives*, 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, beam delivery shall stop until the actions specified above are taken.

If an ASE violation is identified by TJSO and UITF beam delivery is stopped at TJSO's request, beam delivery 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 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 during beam delivery is not conducted in the time-frame specified in the Management and Surveillance description for that Credited Control.
- Moveable shielding identified as a Credited Control is not in place during beam delivery in the accelerator.
- Both independent Personnel Safety System (PSS) channels for the same Credited Control are inoperable during beam delivery in the accelerator.
- A locked access (door or gate) serving as a Credited Control remains unlocked during beam delivery in the accelerator.
- Beam is delivered to an experiment in the accelerator without completing the required experiment review process.
- Beam is delivered in the accelerator with less than the minimum specified qualified staff in the UITF 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 FSAD or may require the addition of a new FSAD hazard along with new Credited Controls. The SCMB operates in collaboration with the TJSO.

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 FSAD, 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 FSAD. 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 Safety Configuration Management Board (SCMB) and approval by TJSO. A management and surveillance interval that expires during beam delivery 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 beam 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 beam delivery. Configuration control is accomplished by the Safety Systems Group Procedures, 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 triennial assessment cycle. This cycle is incorporated into the Annual Assessment Schedule. The management and effectiveness of Credited Controls is evaluated during these triennial assessments.

Certain management and surveillance records, such as verification of the functionality of a Credited Control before beam 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.*

Certain Credited Passive Engineered Controls are listed in the FSAD as initial assumptions (i.e. they are assumed to be in-place and functional prior to the start of accelerator operations. For example, the concrete accelerator enclosure.

Active engineered controls are used when the control requirements are more complex, interactive, or interdependent. Administrative controls are either programmatic in nature or are

embodied in specific operational procedures. Administrative controls, are used last and often in conjunction with engineered controls.

Sections 3.1 – 3.3 below lists the Credited Controls applied to the UITF 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. .

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 beam delivery[1] is possible.

Specific Controls:

- Structural shielding, typically reinforced concrete that defines the accelerator enclosure,
- Built in shielding design features such as labyrinths and 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 or designee (RCM).
- The Dig/Blind Penetration Permit specified in Environment, Safety and Health (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.

[1] Gun high voltage processing and/or cathode re-cesiation and gun operation (producing electrons at energy up to the applied bias voltage on the gun) is not considered beam delivery in this ASE.

- Structural shielding shall be inspected as specified by Facilities Management and Logistics (FM&L) and recorded in the Maximo work order system at least every five years. The inspection results shall be communicated to the RCM.
- RCM shall evaluate all permanent shielding at least every five years against applicable design specifications and FSAD requirements, and its general condition with respect to shielding effectiveness. The evaluation shall be recorded in the Beam Authorization Tool (BAT) for the run period identified in the BAT.

Acceptable Compensatory Measures:

If RCM evaluation determines the condition of permanent shielding associated with an accelerator enclosure does not meet requirements specified in the FSAD or is otherwise unacceptable, the RCM Manager will recommend compensatory measures (such as additional access control, installation of temporary shielding, etc.), if necessary, to maintain performance specified in the *Jefferson Lab Shielding Policy for Ionizing Radiation* until the shielding is restored to the values specified in the FSAD or the FSAD 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:

When beam delivery is possible.

Specific Controls:

Movable shielding[2].

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

Management and Surveillance:

- Moveable shielding shall be subject to the *Jefferson Lab Shielding Policy for Ionizing Radiation*.
- Moveable shielding design and changes shall be reviewed in accordance with the ASE Violation/USI Review Process and approved by the Radiation Control Manager or designee (RCM).
- For PSS non-interlocked Movable Shielding, locking devices and/or tags installed consistent with *ES&H Manual Chapter 6111, Administrative Control Using Locks and Tags* shall be used to identify moveable shielding. Note: Labeling or tagging is not required for shielding sections if they are part of the concrete structure that defines the UITF accelerator enclosure and, once placed, they are not intended to move to facilitate UITF operation.
- The RCM shall record the Movable Shielding status, along with the expiration date for the status determination, in the UITF BAT before beam delivery.
- Correct placement of moveable shielding shall be verified in accordance with the Jefferson Lab *Radiation Control Department Procedures* specified in *HPP-OPS-002, Performance of Periodic Routines.*

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*.

4.1.3. Nitrogen Gas Supply Orifices

Applicability:

When an affected system is charged with gas and personnel are in the affected area within the accelerator enclosure.

Specific Controls:

Orifices in the supply lines restrict the flow rate to levels that would be dispersed through normal area ventilation without significantly reducing the oxygen concentration.

Management and Surveillance:

- Orifice in place and labeled consistent with *ES&H Manual Chapter 6111 Administrative Control Using Locks and Tags*.
- Facilities Management and Logistics shall record the Nitrogen Gas Supply Orifice status, along with the expiration date for the status determination, in the UITF BAT before beam delivery.

Acceptable Compensatory Measures:

Work control procedures for work in affected area shall specify Oxygen Deficiency Hazard (ODH) mitigation as required by the *ES&H Manual Chapter 6540 Oxygen Deficiency Hazard (ODH) Control Program*.

4.1.4. ODH Vents, Lintels and Facility Configuration

Applicability:

When Quarter Cryomodule is supplied with cryogens or Target is supplied with cryogens.

Specific Controls:

UITF passive vents in accelerator enclosure and passive vents incorporated into moveable shielding.

Management and Surveillance:

- No surveillance is required for these controls if they are part of a concrete structure that defines the UITF accelerator enclosure and, once placed, they are not intended to move to facilitate UITF operation.
- Passive vents, incorporated into moveable shielding and identified as Credited Controls, are visibly labeled or tagged consistent with *ES&H Manual Chapter 6111 Administrative Control Using Locks and Tags* and verified after movement.
- Facilities Management and Logistics shall record the status of passive vents incorporated into moveable shielding and identified as Credited Controls, along with the expiration date for the status determination, in the UITF BAT before beam delivery.

Acceptable Compensatory Measures:

Work control procedures for work in affected area shall specify ODH mitigation as required by the *ES&H Manual Chapter 6540 Oxygen Deficiency Hazard (ODH) Control Program*.

4.2. Credited Active Engineered Controls

Active Engineered Controls include the PSS and the ODH Monitoring systems. The PSS provides monitoring of the access points of the accelerator in order to keep people from beam-related radiation hazards. In combination with Passive Engineered Controls such as shielding and Administrative Controls such as doors, gates, fences, etc. the PSS serves to keep people away from beam. The ODH System provides monitoring of oxygen levels in the accelerator in order to protect people from ODH caused by the release of oxygen displacing gases.

4.2.1. PSS Access Controls

Applicability:

When beam delivery is possible.

Specific Controls:

The UITF PSS shall have no loss of safety function during beam delivery[3].

Management and Surveillance:

- UITF PSS components shall be visibly labeled or tagged consistent with *ES&H Manual Chapter 6111 Administrative Control Using Locks and Tags*.
- Interim changes to the PSS are reviewed and approved in accordance with the *PSS Configuration Control Policy* and the *ASE Violation/USI Review Process*. PSS functional requirements are established in the *Beam Containment and Access Control Policy*.
- The UITF PSS shall be certified annually.
- The Safety Systems Group shall verify the status of the UITF PSS, along with the expiration date for the status determination, in the UITF BAT by before beam delivery.

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

4.2.2. ODH System Controls

Applicability:

When required by the *ES&H Manual Chapter 6540 Oxygen Deficiency Hazard (ODH) Control Program* and an ODH analysis document, a fixed ODH monitoring system shall be installed in UITF areas.

Specific Controls:

An ODH system shall provide adequate monitoring coverage of the affected areas.

Management and Surveillance:

- UITF ODH system components shall be visibly labeled or tagged consistent with ES&H Manual Chapter *6111 Administrative Control Using Locks and Tags*.
- The system shall be maintained such that it is operational when required by the ODH assessment for the location.
- Maintenance shall be performed in accordance with Safety Systems Group procedures.
- ODH sensing devices shall be tested every two years.
- The Safety Systems Group shall verify the status of ODH System Controls, along with the expiration date for the status determination, in the UITF BAT by before beam delivery.

Acceptable Compensatory Measures:

- Entry only by authorized personnel in accordance with *ES&H Manual Chapter 6540 Oxygen Deficiency Hazard (ODH) Control Program* requirements for entry into a reduced oxygen atmosphere.
- Exclusion of personnel from the areas in which the ODH system performance is inadequate.

4.3. Credited Administrative Controls

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

4.3.1. Doors, Gates, Fences, and other Barriers

Applicability:

When beam delivery is possible.

Specific Controls:

Entrances to the UITF accelerator enclosure shall be interlocked via the PSS Interlocks or locked, barred, or bolted into place to prevent unauthorized access.

Management and Surveillance:

- Doors, gates, fences, and other barriers serving as Credited Controls shall be clearly identified by visible labels or tags consistent with *ES&H Manual Chapter 6111 Administrative Control Using Locks and Tags.*
- Access shall only be permitted in accordance with approved procedures. Keys shall be controlled and issued to authorized personnel.
- The RCM shall verify the locked, barred, or bolted entrances in accordance with the *Radiation Protection Department Procedures* specified in *HPP-OPS-002, Performance of Periodic Routines.* The status, along with the expiration date for the status determination, shall be recorded in the UITF BAT.

4.3.2. Lab Experimental Review Processes

Applicability:

When beam delivery is possible to a designated experiment.

Specific Controls:

- Any experiment that has completed the Proposal Phase (i.e. the experiment has a decision, formally communicated by the Physics Advisory Committee report and a letter from the Laboratory Director granting beam-time) will undergo the remaining experimental review process steps as described in the ES&H Manual Chapter 3120 The

CEBAF Experiment Review Process before the experiment is run using the UITF accelerator.

- A proposed experiment that will not undergo the experimental review process steps as described in the ES&H Manual Chapter 3120 described above shall follow the requirements in the ES&H Manual Chapter 3130 Accelerator Experiment Safety review Process.

Management and Surveillance:

ES&H Manual Chapters are maintained in accordance with *ES&H Manual Chapter 1300 Content Review Process.*

4.3.3. Staffing – Sweep

Applicability:

When UITF is being made ready for PSS state above Open Access.

Specific Controls:

The minimum requirements for staffing during a Sweep is one qualified UITF operator. *(UITF Operations Directives* addresses minimum staffing requirements.)

Management and Surveillance:

Trained UITF staff carry out UITF Sweeps follow the steps defined in the specific sweep procedure maintained by the Safety System Group.

4.3.4. Staffing – Operations

Applicability:

When UITF PSS is being made ready for PSS state above Open Access.

Specific Controls:

The minimum requirements for staffing during accelerator operation is one qualified UITF operator. *(UITF Operations Directives* addresses minimum staffing requirements.)

Management and Surveillance:

Trained UITF Operators, in the UITF Control Room, perform UITF operations following the steps defined in the *UITF Operations Directives.*

DOCUMENT LIST (Alphabetical Order)

Accelerator Division Controls Software Group User Account/Usage Policy
ASE Violation/USI Review Process
Accelerator Safety Envelope (ASE)
Beam Containment and Access Control Policy
Department of Energy (DOE) Order 420.2C Safety of Accelerator Facilities (ASO)
ES&H Manual Chapter 1300 Content Review Process
ES&H Manual Chapter 3120 The CEBAF Experiment Review Process
ES&H Manual Chapter 6111, Administrative Control Using Locks and Tags
ES&H Manual Chapter 6540 Oxygen Deficiency Hazard (ODH) Control Program
Jefferson Lab Final Safety Assessment Document (FSAD)
Jefferson Lab Shielding Policy for Ionizing Radiation
PSS Configuration Control Policy
Radiation Control Department Procedures - HPP-OPS-002, Performance of Periodic Routines
Site-Wide Cyber Security Program
UITF Operations Directives

ACRONYMS

Acronym	Definition	Page
ASE	Accelerator Safety Envelope	1
ASO	Safety of Accelerator Facilities	1
BAT	Beam Authorization Tool	7
DOE	Department of Energy	1
FM&L	Facilities Management and Logistics	7
FSAD	Final Safety Assessment Document	1
Jefferson Lab	Thomas Jefferson National Accelerator Facility	1
PSS	Personnel Safety System	5
RCM	Radiation Control Manager (or designee)	7
SCMB	Safety Configuration Management Board	1
TJSO	Thomas Jefferson Site Office	1
UITF	Upgraded Injector Test Facility	1
USI	Un-reviewed Safety Issue	5