Jefferson Lab
Thomas Jefferson National Accelerator Facility

# Operational Safety Procedure Form

**(See ES&H Manual Chapter 3310 Appendix T1 Operational Safety Procedure (OSP) and Temporary OSP Procedure for instructions.)**

Click For Word Doc

| | | | | | |
|---|---|---|---|---|---|
| **Title:** | keV beam line of the Upgraded Injector Test Facility (UITF) | | | | |
| **Location:** | Test Lab High Bay Area, room 1127-1129 | | | **Type:** | [X] **OSP** [ ] **TOSP** |
| **Risk Classification** (per Task Hazard Analysis attached) (See *ESH&Q Manual Chapter 3210 Appendix T3 Risk Code Assignment*.) | | | | **Highest Risk Code Before Mitigation** | 3 |
| | | | | **Highest Risk Code after Mitigation (N, 1, or 2):** | 1 |
| **Owning Organization:** | Center for Injectors and Sources, Accel. Div. | | **Date:** | February 24, 2017 | |
| **Document Owner(s):** | Matthew Poelker | | | | |

## DEFINE THE SCOPE OF WORK

**1. Purpose of the Procedure –** Describe in detail the reason for the procedure (what is being done and why).

The purpose of this OSP is to describe in detail the procedures for safely operating the keV region of the UITF.

FSAD Rev. 7a considered the Injector Test Facility to be a Technical Area containing one or more accelerator components that did not constitute an accelerator and did not create hazards that presented an unacceptable risk (require the use of credited controls for hazard mitigation). FSAD Rev. 8, in DRAFT, considers the Upgraded Injector Test Facility (UITF) to be an accelerator, analyzes the hazards, and specifies the hazard mitigations. This OSP provides the basis for operating the keV region of the UITF and is consistent with the requirements in FSAD Rev. 8 DRAFT.

* Final Safety Assessment Document Rev 7a: https://jlabdoc.jlab.org/docushare/dsweb/View/Collection-4440

**2. Scope –** include all operations, people, and/or areas that the procedure will affect.

***UITF operation with keV beam***

There are two modes of operation:

1. Tune beam (pulsed) at voltage up to 450 kV (average current typically 100 nA)
2. CW beam administratively limited to 3 mA when using the 450kV power supply and 32 mA when using the 225kV supply.

The affected area is Cave 1 (See figure 1)

**3. Description of the Facility –** include building, floor plans and layout of the experiment or operation.

The location of UITF is the High Bay Area of the Test Lab. Figure 1 shows the UITF lay out and identifies Caves 1 & 2. This OSP covers keV beam operations which occur only in Cave 1. Figures 1 and 2 show the labyrinth, which is the main access to UITF. Figure 3 shows UITF with concrete shielding over the roof of Cave 1. Electronics racks are located above Cave1. In Figure 3, for illustration purposes only, the roof of Cave2 is shown removed.

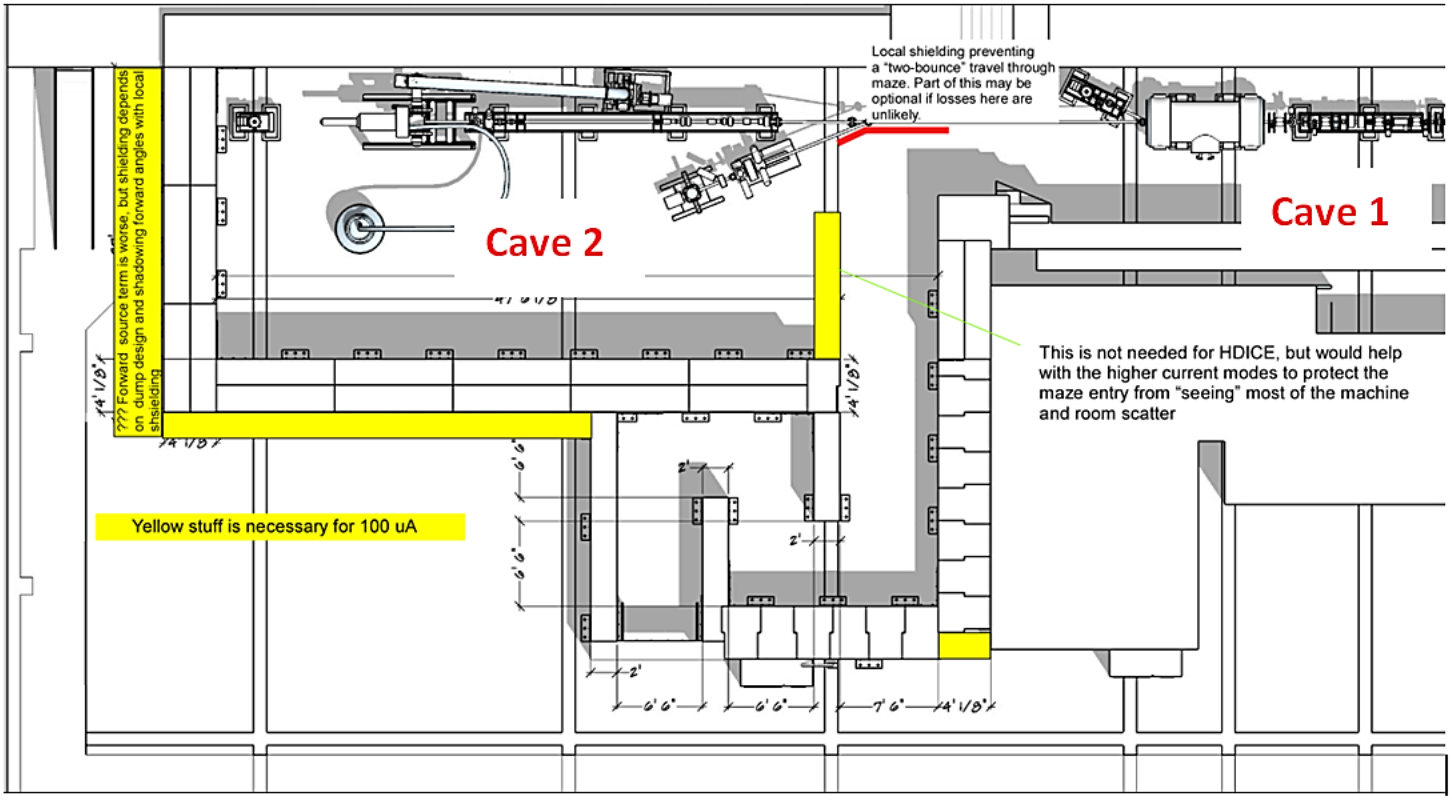



Figure 1 UITF beamline layout showing the two Caves. keV beam is confined to Cave 1

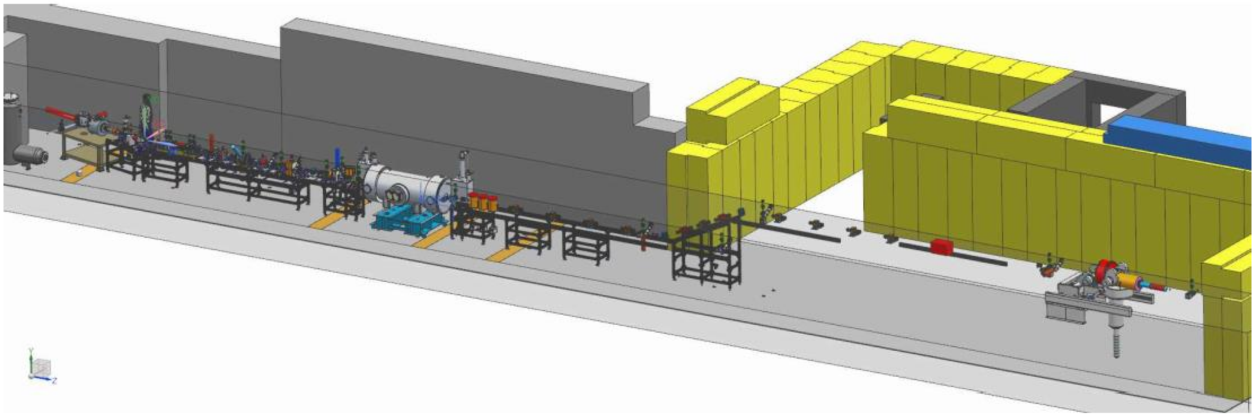


Figure 2 UITF layout showing the exit to main entrance through labyrinth towards the high bay area

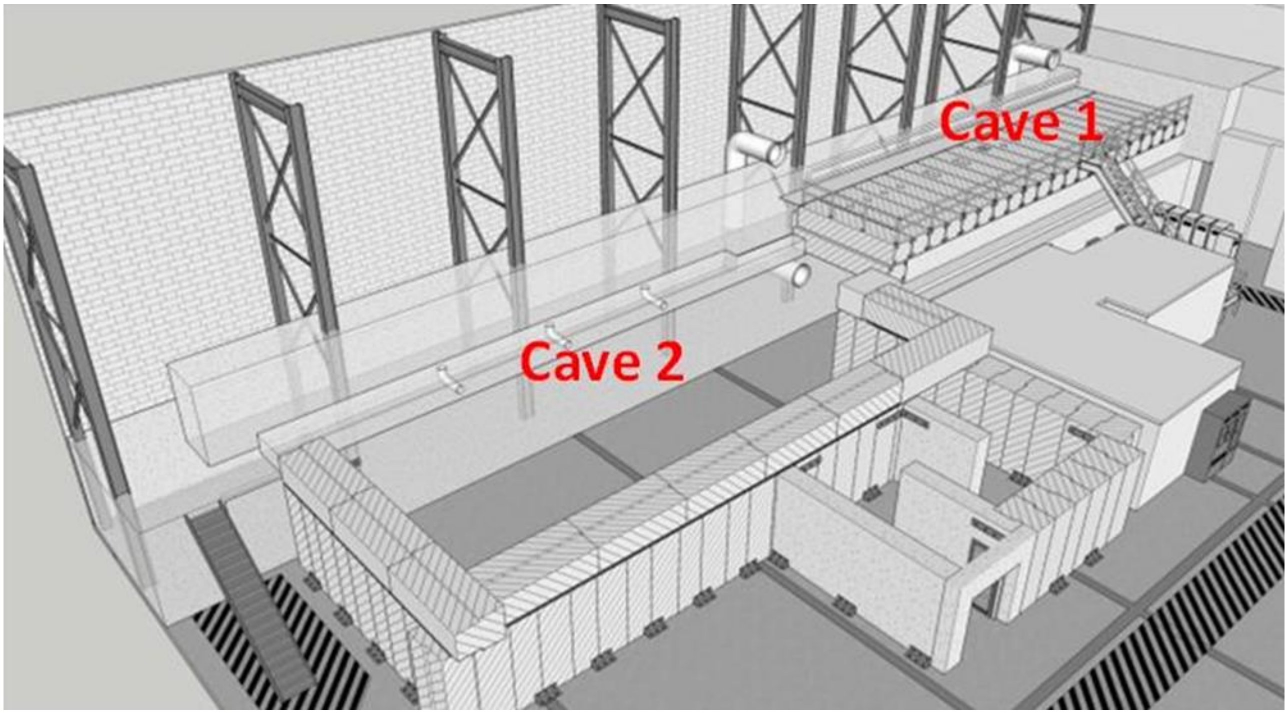



Figure 3 UITF layout showing the main entrance Labyrinth and shielded roof of Cave 1

## ANALYZE THE HAZARDS and IMPLEMENT CONTROLS

**4. Hazards identified on written Task Hazard Analysis**

Refer to attached Task Hazard Analysis Work Sheet for details and mitigation. The following lists the hazards.

1. Ionizing Radiation
2. Laser non-ionizing Radiation
3. RF Non-ionizing Radiation
4. Magnetic Fields
5. Oxygen Deficiency
6. Electrical
7. Pressure / Vacuum
8. SF6 toxicity

**5. Authority and Responsibility:**

**5.1 Who has authority to implement/terminate**

Matthew Poelker

**5.2 Who is responsible for key tasks**

Matthew Poelker

**5.3 Who analyzes the special or unusual hazards including elevated work, chemicals, gases, fire or sparks** (See ES&H Manual Chapter 3210 Appendix T1 Work Planning, Control, and Authorization Procedure)

Ionizing Radiation – Vashek Vylet
Laser non-ionizing radiation – B. Manzlak, J. Williams

RF Non-ionizing radiation – J. Williams, M. Brown
Oxygen Deficiency – J. Williams
Electrical – T. Kujawa
Lead – M. Brown
SF6 toxicity – J. Williams
Fire – Ed Douberly
Safety Warden – J. Hansknecht
Pressure / Vacuum – W. Oren

**5.4 What are the Training Requirements** (See http://www.jlab.org/div_dept/train/poc.pdf)

UITF Operators must have the following Training

- SAF 100 – ES&H Orientation
- SAF 307 – Ladder Safety
- SAF 1140 – Laser Orientation
- SAF603A – Electrical Safety Awareness: Classes, Modes, etc.
- SAF 103 – Oxygen Deficiency Hazard
- SAF 104 – Lock, Tag and Try
- SAF 801– Rad worker
- SAF130AU – Pressure Systems Safety Awareness for Users
- SAF136 – Lead Worker Safety Awareness
- Read and sign this OSP

**6. Personal and Environmental Hazard Controls Including:**

**6.1 Shielding**

The keV beam line is operated in tune mode or CW mode. The tune mode beam is a pulsed beam at 60 Hz averaging 100 nA of beam current. In CW mode, the average beam current can be up to 3 milliamps when using the 450 kV power supply and 32 mA when using the 225 kV power supply.

Cave 1 has 30” concrete shielding on the roof. The penetrations have 3.5” iron shielding (figure 4 below)

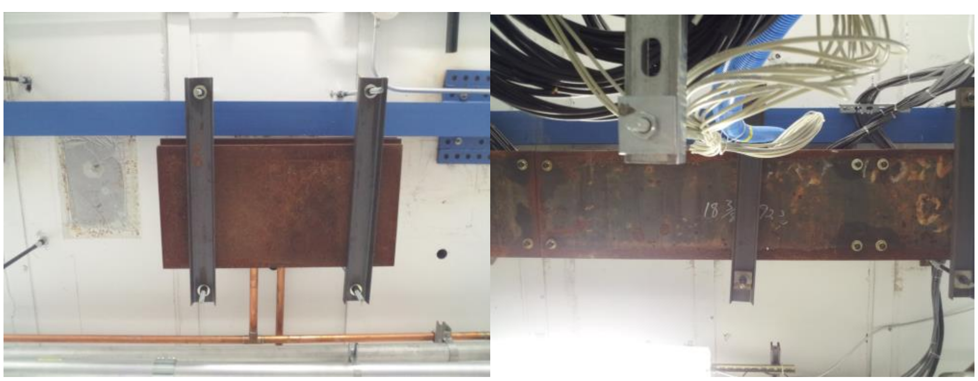


Figure 4 Steel plates covering penetrations in Cave 1. Cables pass through the penetrations linking the electronics racks and beamline elements.

The keV beam termination points are beam dumps and Faraday cups in Cave 1. Radiation Control Department (RCD) approved local shielding will mitigate radiation hazards. Of the two walls in Cave 1, the east wall (see figure 1) is many meters thick and is an effective radiation barrier. The west wall is 36” thick. The local shielding on the dumps will mitigat radiation hazard.

During beam operations, the entire roof area of Cave 1 will have signage and be roped off preventing access.

RCD will measure the radiation at the roof and the UITF walls in the high bay area at various beam currents to experimentally determine the current limits. Any additional shielding measures or reduction in measures will be described in an amendment to this OSP based on these radiological measurements.

The main entrance labyrinth and the south access labyrinth prevent line of sight exposure to x-ray radiation.

**6.2 Barriers** (magnetic, hearing, elevated or crane work, etc.)

1. Vacuum windows: The UITF beam line is under vacuum. If work involves thin windows (which is not anticipated), there will be signage warning personnel entering UITF that hearing protection is mandatory for entrance. Hearing protection will be available in well-marked containers.
2. Magnetic Fields: The magnets at UITF can be energized when the UITF is OPEN but these magnets have fields that off to less than 5 gauss within a few inches from the magnet. If there are cases where the field is > 5 gauss at a foot or more, there will be barriers to prevent personnel from exposure to the magnetic field.
3. The magnets have electrical terminals which are either insulated or have protective covers to prevent accidental contact.

**6.3 Interlocks**

The UITF’s Personnel Safety System (PSS) protects personnel from being exposed to prompt radiation. Personnel exposure is prevented through both administrative (sweep procedures, postings) and engineered (concrete enclosures, gates, and interlocks) means. UITF (see Figure 5) is a completely enclosed area. No one is allowed inside the enclosure during beam operations, or gun high voltage conditioning, or when high power RF is applied to the buncher or the SRF quarter cryomodule.

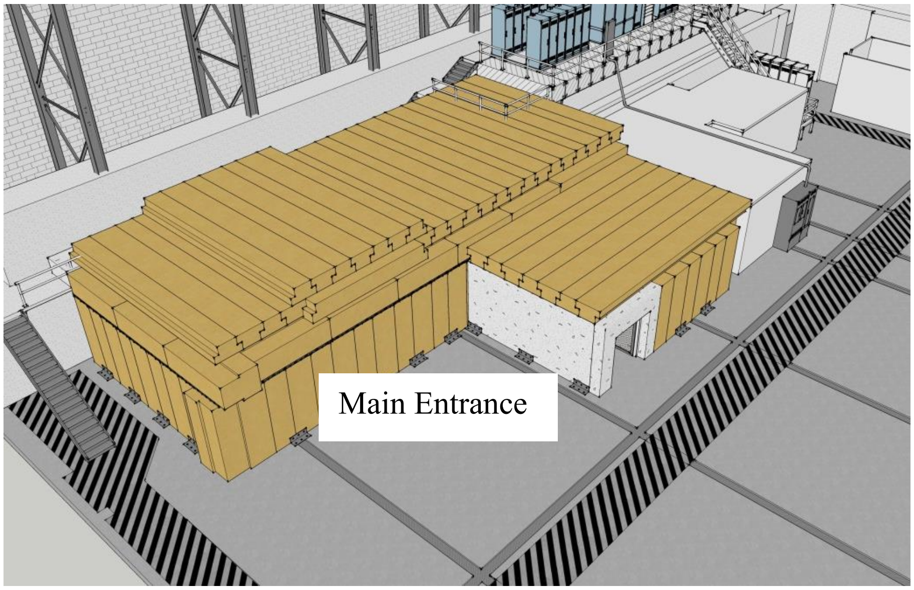


Figure 5 UITF With concrete shielding in place

Figures 6 and 7 show the two entry/exit ways to and from the UITF, the run safe box, signage along with the warning beacons.

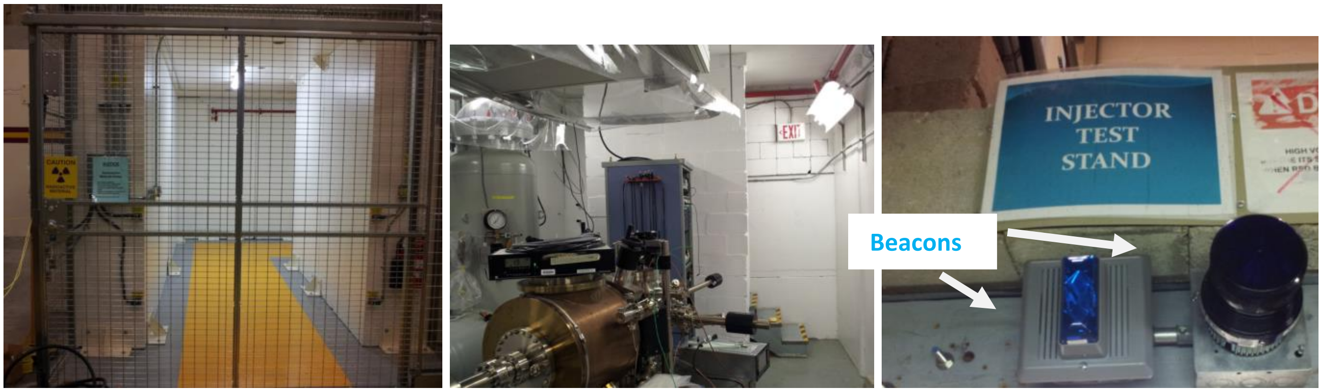



Figure 6 (Left) Main entrance/exit from high bay area through the labyrinth of UITF (Middle), Secondary exit into the high bay from the southern-most location of the keV section. Both doors have Personnel Safety System interlocks and emergency exit switches on the nearby walls (Right). Beacons exist at both entrance/exit ways


Figure 7 (Left) Exit into high bay from Cave 1 near the electron gun (Middle) Run/Safe Box (Right) Crash Switch for exit Run/Safe Boxes and Crash switches are at both the entrance/exit ways

During normal operations, the main entrance/exit will be in use. The secondary exit door can be used as needed, but is primarily considered an emergency exit.

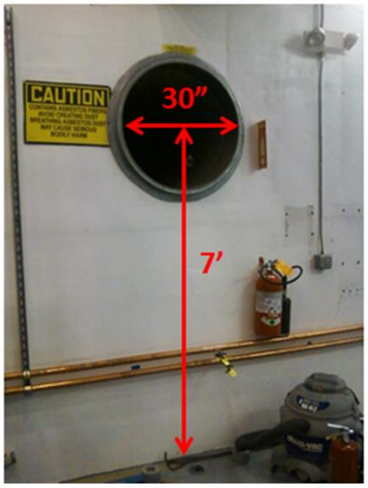
The main and secondary entrance/exit doors are part of the PSS. The PSS interlocks are attached to the gun high voltage power supply, the drive laser shutter and the high power RF system. CARMs located outside the enclosure are interlocked to the PSS. The PSS will turn OFF beam when door interlocks are breached or when CARMs indicate excessive radiation measured outside the enclosure.

**6.4 Monitoring systems**

There are three monitoring systems. One is the PSS, explained above, which provides access control to the UITF and protects personnel from prompt ionizing radiation associated with UITF operation. The second is the ODH system, which alarms when the oxygen level in the UITF enclosure drops below 19.5%. The third monitoring system relates to the pressure within the SF6 tank that houses the Glassman gun high voltage power supply. There is a digital pressure gauge that monitors SF6 pressure, and can be configured to "alarm" when pressure falls below a User specified level. The alarm is a Yellow LED that illuminates at the SF6 tank. The alarm is also an EPICS signal. The alarm is triggered when pressure drops from 60 to 58 psi. Finally, there is an Ashcroft pressure switch that will shut off the Glassman HV power supply when SF6 pressure falls below 45psi.

## 6.5 Ventilation

There are two fans on the east wall of Cave 1 (Figure 8). In addition, there are three 0.15 m (6") diameter vent holes on the west wall near the ceiling and two 0.3m x 0.3m (12"x12") square vents. These square vent holes have chimneys attached to them on the ceiling. The height of the chimneys is about 7 ft. which will mitigate any hazard in the unusual event of cryogenic gas release in Cave 1. The existence of these fans is included for completeness of information, however the ODH assessment of UITF does not take credit for the existence of these fans. The ODH assessment (preliminary, see below) and the SF6 exposure assessment are attached to this OSP and can be found at:
https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-135009/UITF%20prelim_%20ODH%20assessment.pdf



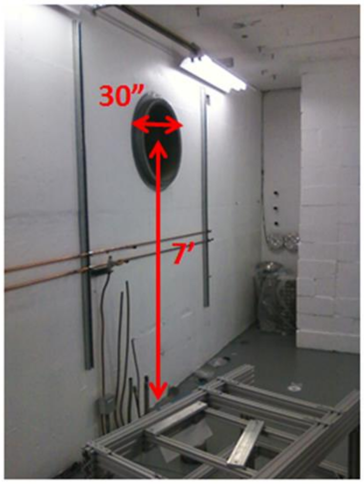


Figure 8 (Left) Fan with a capacity of 7400 CFM vents air into the high bay area, (middle) fan with a capacity of 4400 CFM vents air to outside the test lab, right two chimneys attached to the square vent holes in the ceiling of Cave 1

There is a passive 5.6 $m^2$ vent beneath the raised roof of Cave 2 (Figure 9) to vent lighter than air cryogens into the high bay area in the unlikely event of an equipment failure of experimental targets (e.g. HD-ICE). The existence of this vent area is not relevant to keV beam operations and is included for completeness of information.

Figure 9 (Left) Shielded elevated-roof section of Cave 2, which will be used for experimental targets, including cryogenic targets. (Right) 5.6 $m^2$ Vent area beneath the elevated roof section of Cave2, for lighter than air cryogenic gases to escape.

### 6.6 Pressure / Vacuum

The evacuated photogun and keV beamline is considered a Category 0 vacuum system, per Part 7 of the Pressure Safety Supplement. Specifically, the cross section of the vacuum system does not exceed 33 square inches, the relieving vacuum cannot exceed 15 psi, there are no cryogenic components, and there are no thin walled components that could rupture.

### 6.7 Other (Electrical, ODH, Trip, Ladder) (Attach related Temporary Work Permits or Safety Reviews as appropriate.)

The manuals for photogun high voltage systems can be found at: https://wiki.jlab.org/ciswiki/index.php/ITF21 Manuals clearly state that the high voltage power supplies must be de-energized before work is performed, in accordance with JLab LTT policy.

The ODH assessment for the UITF is attached. It is deemed "preliminary" until the complete MeV beamline has been constructed and the ODH-related recommendations have been implemented and verified adequate. This assessment can be found at:
https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-135009/UITF%20prelim_%20ODH%20assessment.pdf

See Section 5.3 above for a complete list of hazards.

## 7. List of Safety Equipment:

### 7.1 List of Safety Equipment:

1. Safety glasses when performing mechanical work, as needed
2. Gloves depending on mechanical or shielding work
3. Hard hats and/or steel toed boots depending on materials handling needs

4. Laser safety goggles, as required by LOSP (ACC-17-64784-LOSP)

**7.2 Special Tools:**

n/a

## 8. Associated Administrative Controls

- Safety Systems Group staff is responsible for:
  - PSS administrative and engineered controls
  - Training on access controls and sweep procedures

- Radiation Control Department staff is responsible for:
  - Maintenance and calibration of fixed interlocked and hand held radiation monitors
  - Area and personnel dosimeters
  - Radiation surveys
  - Assigned Radiation Monitor Training (if needed)

- Center for Injectors and Sources (CIS) staff is responsible for:
  - LSS administrative controls
  - $SF_6$ Gas insulated HVPS administrative and engineered controls
  - Locking and Tagging the Faraday cup in front of the ¼ cryomodule for keV mode operation

The Faraday cup in front of the ¼ cryomodule is inserted and locked in place for all keV mode operations. The valve to the ¼ cryomodule is CLOSED and cannot be opened via EPICS (i.e., the compressed air line is NOT attached to the OPEN spigot of the valve mechanism)

*Administrative controls includes: Authority/responsibility, Procedures, Postings, and PPE

- CIS personnel are responsible for safe operation of the UITF. This includes limiting beam power to fall within the identified operations and safety parameters.
- UITF's PSS logic manages the two door switches and the Run/Safe Boxes to provide an "Area Secure" signal to the PSS logic
- The HVPS control unit is interlocked to the PSS, it cannot be energized unless the PSS is in "Run" mode, attained after the UITF enclosure has been swept.
- The laser shutter is interlocked to the PSS and LSS.
- The CARMs/radiation probes are interlocked to the PSS.
- High power RF (for buncher and ¼ cryomodule) is interlocked to the PSS

# DEVELOP THE PROCEDURE

## 9. Operating Guidelines

The UITF's keV beam is operated under this Operational Safety Procedure, which addresses hazards associated with maintenance and operation and their mitigations through engineered and administrative controls. Fault conditions in the UITF can produce only local work area impacts.

**Staffing**

The UITF can be operated by a single trained and authorized user (typically the personnel conducting gun and/or beam studies). During keV beam operations, tests can happen in unattended mode, for example a long beam run to measure the photocathode charge lifetime.

**UITF Operation**

PSS state for the UITF is either: Open Mode (open access), Sweep Mode, Ready Mode and Run Mode. Ready Mode is an internal (logical) mode confirming that all interlocks are ready for transition to Run Mode.

Prior to beam operations, the laser bypass key must be returned to the PSS console in the Control Room in order to energize the gun high voltage power supply. In addition, the UITF must be placed in Open Mode using the Personnel Safety System (PSS) and the doors must be properly configured (i.e., closed). The sweep procedure is described in Section 11.

**UITF Operator Requirements**

In addition to the training listed in section 4.4, the UITF operator must:

1. Read and understand this OSP that includes PSS sweep procedures,
2. Receive the practical training on this OSP and on UITF operational procedures from system owner (Matthew Poelker or designee)
3. Perform walkthrough of the following areas: UITF control room and Cave 1 roof where the electronics racks are located.

**10. Notification of Affected Personnel (who, how, and when include building manager, safety warden, and area coordinator)**

Safety: UITF Safety Warden, John Hansknecht 269-7097
UITF system owner: Matthew Poelker, office 269-7357, cell. 757-897-9408

**11. List the Steps Required to Execute the Procedure:** from start to finish.

**keV beamline**

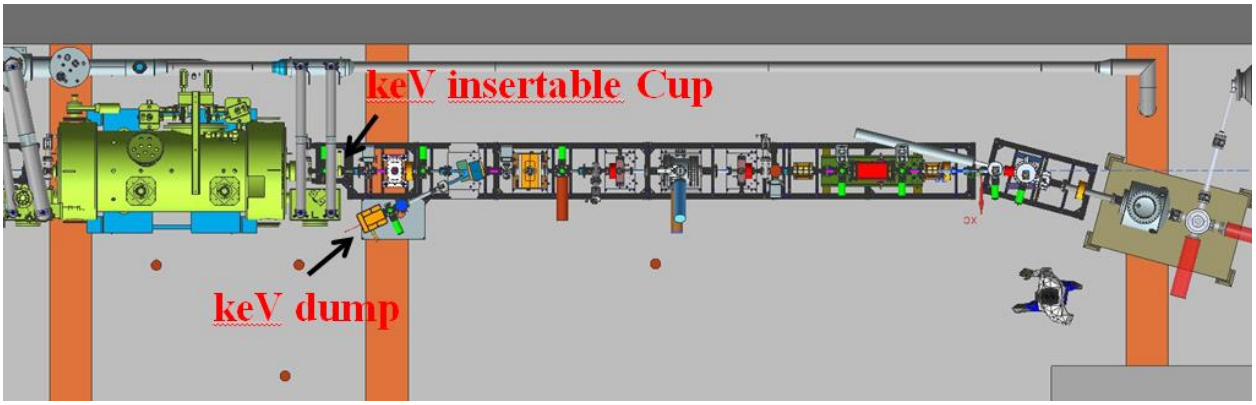



Figure 10 keV beam line top views. The figure shows the location of the 1/4 Cryomodule, the keV fixed dump, and the keV insertable Faraday Cup

The beam termination points such as the Faraday cup in front of the ¼ cryomodule, apertures and beam dump will have additional local shielding in compliance with Radiation Control Department's assessment.

During the transportation of the electron beam from the gun, whether in Tune mode or CW mode, there can be beam losses. This is especially true during commissioning with beam. The beam loss monitors (BLMs), will detect the beam losses and shutter the laser, terminating beam production. While this will protect the beam line from venting during CW operations, this can become a nuisance during beam tune up. The control system allows masking of the BLMs during Tune mode operations. Proper BLM response with a radioactive source is a requirement prior to their installation in the beam line.

The following describes the operating procedures for keV beam line.

**Procedure:**

**In the UITF**

1. Insert Faraday cup at the entrance of ¼ Cryomodule. Lock and Tag the cup. Verify that the valve in front of the ¼ cryomodule is CLOSED and cannot be opened via EPICS (i.e., the compressed air line is NOT attached to the OPEN spigot of the valve)
2. The following is an overview of the PSS sweep. Use the complete detailed sweep procedure and map attached to this OSP. A copy will also be maintained in the Control Room.
   i) Post the top (mezzanine) of Cave 1 as a restricted area
   ii) Inform all occupants to leave the UITF enclosure
   iii) Close both doors

iv) Go to control room and turn key to SWEEP

v) Enter the enclosure through the back door, close door behind you upon entry

vi) Arm RunSafe Box601 in the hallway

vii) Sweep the enclosure, walking all the way to the north wall of Cave2

viii) Verify the Faraday Cup is locked in place, and the valve to the ¼ cryomodule is locked CLOSED

ix) Arm RunSafe Box602 near labyrinth exit

x) Exit through the labyrinth closing screen gate door completely

xi) Return to control room, turn key to RUN to arm the Personnel Safety System

**In the Control Room**

1. Turn ON the gun high voltage
2. Set up Viewer Limited Mode.
3. Load the nominal optics file and look for beam on viewers (viewer limited mode, very low duty factor), working from the gun to the dump, using steering magnets as necessary. Adjust solenoid fields to obtain the desired beam size along the beamline.
4. Turn on the BLMs, take beam to Tune Mode, 8uA
5. Steer the beam to deliberately cause beam loss and ensure that the BLMs detect the beam loss and shut off the beam.
   a. If BLMs do not respond as expected, terminate beam operations and diagnose the BLMs with a radioactive source.
6. Once the BLMs are responding as expected, establish beam to the Faraday cup.
7. Verify that the Beam Position Monitors are reading back
8. Establish buncher and chopper settings using Harps and viewers, until the Tune beam looks ‘good’ in the spectrometer line
9. Set CW beam current to 100 nA and ensure that the beam transports cleanly to the Faraday cup.
10. Turn beam on in tune mode and ensure clean transportation to Faraday cup.
11. Go to 100 nA CW mode
12. Increase the current in steps to the desired permissible beam current
13. Save the keV beamline settings

***Shielding Verification:*** *Contact the Radiation Control Group to verify shielding. This is done by delivering beam to the dump, and RadCon making radiation measurements inside and outside the cave enclosure. This must happen each time a new higher current is produced by the photogun.*

**12. Back Out Procedure(s)** i.e. steps necessary to restore the equipment/area to a safe level.

At any time during UITF operations, the PSS can be brought to OPEN Mode Access, in case there is a need for accessing the enclosure or to conclude high voltage operations.

## Returning the PSS to OPEN Mode in normal operating conditions

- Turn off the gun HVPS from the EPICS control screen
- Turn OFF the buncher RF from EPICS control screens
- Switch the key to "OPEN" mode
- De-post restricted area on mezzanine

**13. Special environmental control requirements:**

**13.1 List materials, chemicals, gasses that could impact the environment** (ensure these are considered when choosing Subject Matter Experts) and explore EMP-04 Project/Activity/Experiment Environmental Review below

SF6 is used as an electrical insulating gas inside the pressurized (60 psi) high voltage power supply.

**13.2 Environmental impacts** (See EMP-04 Project/Activity/Experiment Environmental Review)

SF6 is a greenhouse gas that must be re-used to avoid releasing it into the atmosphere when there is a need to open the tanks, i.e. high voltage power supply maintenance. SF6 is a powerful greenhouse gas, 23,900 times worse than CO2.

**13.3 Abatement steps** (secondary containment or special packaging requirements)

https://wiki.jlab.org/ciswiki/index.php/SF6_Inventory_and_Handling_Procedures

**14. Unusual/Emergency Procedures** (e.g., loss of power, spills, fire, etc.)

## Returning the PSS to OPEN Mode in case of emergency or any other abnormal conditions

At any moment the PSS Safety Crash buttons can be depressed. This action will cut off the gun high voltage power supply, turn OFF high power RF, and will close the laser shutter if those systems are operational. It will also crash the sweep and will force unlock the doors.

Since ionizing radiation is present in the enclosure only when the gun is at high voltage, depressing any of the PSS RunSafe or Control Room crash buttons will restore the area to a safe level. NOTE: the emergency exit crash switch will only release the local door lock.

The following is a list of currently installed alarms:

1. ODH (blue strobe + buzzer)
2. Fire (white strobe + high pitch)
3. SF6 pressure sensor on Glassman high voltage power supply SF6 tank
4. Potential prompt radiation (magenta strobe beacon and 30 second siren)

The expected response to any of the alarms is to evacuate the UITF enclosure immediately and proceed to the high bay area of the Test Lab

Return to normal operations occurs when alarms are cleared by the following personnel:

1. ODH cleared by SSG or CIS Staff
2. Fire cleared by Facilities Management
3. SF6 CIS staff, SF6 custodian, UITF Safety Warden responsibility

Comments regarding SF6 hazards: The 45 lbs of SF6 that resides inside the high voltage power supply vessel would occupy 3.2 cubic meters if it were instantaneously released, compared to 207 cubic meter volume of Cave1. Since SF6 is about 5 times heavier than air, it will accumulate on the floor when released from the high voltage power supply vessel. It would reside within a layer less than 1" thick on the floor. However, if it fully mixed with air in Cave 1, the oxygen concentration would fall to ~ 20.5% which is not deemed hazardous (normal oxygen content of 21%). Accounting for the 4400 cfm exhaust fan, it will take ~ 45 minutes to remove all SF6 from the cave (assuming good mixing in the Cave). This time interval does not allow enough time for personnel to exceed the 8-hour exposure limit of 1000ppm. The estimated 8-hour average exposure concentration would be ~ 572ppm.

If the ventilation fan is not operating inside the UITF enclosure, the SF6 will remain along the floor. In this case, personnel are not allowed to work on the floor in case of known leaks.

**Other emergency procedures not covered by alarms are:**

a. Ventilation failure. Expected Response is to evacuate area immediately and convene at muster point.

b. Personnel inside UITF enclosure AND the doors are locked. **NOTE: This event should never occur if proper sweep procedures are followed.** Expected response is to proceed to the nearest Run/Safe Box and press the crash button. Each door has a local crash out button the will release its lock to allow exit. Opening the door will drop the PSS to OPEN mode.

c. Electrical Power failure and in case of personnel trapped inside UITF enclosure. **Personnel Entrapment should never occur if proper sweep procedures are followed.** PSS system will unlock the doors (Electrical power maintains the locks, loss of power unlocks – fail/safe mode)

Notifications:
UITF Safety Warden, John Hansknecht 269-7097
UITF system owner: Matthew Poelker, office 269-7357, cell. 757-897-9408
ODH, Fire: Guard gate 269-5822
Other Emergencies: Guard gate 269-5822

**15. Instrument Calibration Requirements** (e.g., safety system/device recertification, RF probe calibration)

**16. Inspection Schedules**

PSS certification will happen twice per year, scheduled by SSG

**17. References/Associated/Relevant Documentation**

Task Hazard Analysis
LOSP (ACC-17-64784-LOSP)
UITF ODH assessment – preliminary
SF6 exposure assessment

**18. List of Records Generated** (Include Location / Review and Approved procedure)

Operations logbook (electronic)

Click
To Submit OSP
for Electronic Signatures

**Distribution:** Copies to Affected Area, Authors, Division Safety Officer
**Expiration:** Forward to ESH&Q Document Control

**Form Revision Summary**

**Revision 1.4 – 06/20/16 –** Repositioned "Scope of Work" to clarify processes
**Qualifying Periodic Review – 02/19/14 –** No substantive changes required
**Revision 1.3 – 11/27/13 –** Added "Owning Organization" to more accurately reflect laboratory operations.
**Revision 1.2 – 09/15/12 –** Update form to conform to electronic review.
**Revision 1.1 – 04/03/12 –** Risk Code 0 switched to N to be consistent with 3210 T3 Risk Code Assignment.
**Revision 1.0 – 12/01/11 –** Added reasoning for OSP to aid in appropriate review determination.
**Revision 0.0 – 10/05/09 –** Updated to reflect current laboratory operations

| ISSUING AUTHORITY | FORM TECHNICAL POINT-OF-CONTACT | APPROVAL DATE | REVIEW DATE | REV. |
|---|---|---|---|---|
| ESH&Q Division | Harry Fanning | 06/20/16 | 06/20/19 | 1.4 |

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