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Jefferson Lab
Thomas Jefferson National Accelerator Facility

Operational Safety Procedure Review and Approval Form # 144906
(See ES&H Manual Chapter 3310 Appendix T1 Operational Safety Procedure (OSP) and Temporary OSP Procedure for Instructions)

Type:	***OSP*** Click for OSP/TOSP Procedure Form Click for LOSP Procedure Form Click for LOTO-COMPLEX Information Click for LOTO-GROUP Information		
Serial Number:	***ACC-22-144906-OSP***		
Issue Date:	***11/23/2022***		
Expiration Date:	***11/23/2025***		
Title:	***Gun Test stand (GTS)***		
Location: (where work is being performed) Building Floor Plans	***18 - Low Energy Recirculator Facility (LERF) - 109A*** ***18 - Low Energy Recirculator Facility (LERF) - 217***	Location Detail: (specifics about where in the selected location(s) the work is being performed)	***The GTS is located in the west side of the LERF, Building 18. Room 217 is the control room, Room 109A is the shielded enclosure that is under room 217 and adjacent to the LERF vault.***

Risk Classification: (See ES&H Manual Chapter 3210 Appendix T3 Risk Code Assignment)	Without mitigation measures (3 or 4):	***3***
	With mitigation measures in place (N, 1, or 2):	***1***

Reason:	This document is written to mitigate hazard issues that are : ***Determined to have an unmitigated Risk code of 3 or 4***
Owning Organization:	***ACCCIS***
Document Owner(s):	***Suleiman, Riad (suleiman@jlab.org)*** Primary

Supplemental Technical Validations

Lasers Class 3B or 4 (Ultraviolet, Infrared, and Visible Light) (Bert Manzlak, Dainnya Busbin, Jennifer Williams)
ODH 0 and 1 (Dainnya Busbin, Imani Burton, Jennifer Williams)
Controlled Area (Adam Hartberger, David Hamlette, Keith Welch)
Radiological Controlled Area (Adam Hartberger, David Hamlette, Keith Welch)

Document History

Revision	Reason for revision or update	Serial number of superseded document
5	***Expired***	

Lessons Learned	Lessons Learned relating to the hazard issues noted above have been reviewed.
Comments for reviewers/approvers:	***Serial number of superseded document: ACC-19-94662-OSP. Plase note: GTS OSP Rev 03 corrects for a type in section 1: FSAD Rev 8c replaces Rev 7a.***

Attachments

Procedure: ***GTS OSP 2022 Rev03.pdf***
THA: ***GTS THA 2022 Rev02.pdf***
Additional Files: ***TN-07-082_ODH_FEL_Gun Test Stand RevA_final.pdf***

Review Signatures

Subject Matter Expert : Lasers Class 3B or 4 (Ultraviolet-> Infrared-> and Visible Light)	**Signed** on 11/21/2022 8:59:48 AM by Jennifer Williams (jennifer@jlab.org)
Subject Matter Expert : Oxygen Deficiency Hazards (ODH)->ODH 0 and 1	**Signed** on 11/21/2022 8:59:48 AM by Jennifer Williams (jennifer@jlab.org)
Subject Matter Expert : Radiation - Ionizing->Controlled Area	**Signed** on 11/21/2022 8:51:49 AM by Keith Welch (welch@jlab.org)
Subject Matter Expert : Radiation - Ionizing->Radiological Controlled Area	**Signed** on 11/21/2022 8:51:49 AM by Keith Welch (welch@jlab.org)

Approval Signatures

Division Safety Officer : ACCCIS	**Signed** on 11/21/2022 9:28:44 AM by Harry Fanning (fanning@jlab.org)
Org Manager : ACCCIS	**Signed** on 11/23/2022 10:50:25 AM by Joe Grames (grames@jlab.org)

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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.)

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Title:	**Gun Test stand (GTS)**		
Location:	Building 18 (LERF), room 217 (GTS control room) and room 109A (GTS enclosure).	**Type:**	☒ **OSP** ☐ **TOSP**
Risk Classification (per Task Hazard Analysis attached) (See *ES&H 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:	ACCCIS	**Date:**	November 16, 2022
Document Owner(s):	Carlos Hernandez-Garcia		

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 safe operating procedures for conducting photocathode gun and electron beam studies in the Gun Test Stand (GTS) at LERF.

The GTS consists of a DC electron gun and a beam line, it is considered in the FSAD* to be an accelerator component test stand and does not contain accelerating cavities or components designed to impart energy to the electrons beyond the voltage potential across the gun; a few hundred-kilo electron-Volts (keV). Its principal use is to test photocathode material performance and electron gun configurations.

* Final Safety Assessment Document Rev 8c: https://jlabdoc.jlab.org/docushare/dsweb/View/Collection-4440

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

The GTS is not considered an accelerator; it is not a user facility and does not conduct nuclear physics experiments.

GTS operations & maintenance are conducted by the Center for Injectors and Sources (CIS) personnel.

This operating procedure applies to the area known as the Gun Test Stand (GTS). The GTS is located in the west side of the LERF, Building 18. Room 217 is the control room, Room 109A is the shielded enclosure that is under room 217 and adjacent to the LERF vault.

Nominal operations are limited to the following modes:

- Tune-up beam (AKA viewer limited) at either 350 kV administratively limited to less than 100 micro-Amps average current.
- 350 kV at 5 mA CW max limited by the power supply

The gun high voltage power supplies, the laser hutch doors and the laser power units are interlocked to the GTS Personal Safety System (PSS). The cathode solenoid coil is not part of the PSS but it interlocked to the sliding concrete door, which is interlocked to the PSS.

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

The Gun Test Stand is located on the west side of the LERF (Building 18) and consists of a control room (Bldg 18, room 217) and an enclosure (Bldg 18, room 109A) with concrete shield walls that is under room 217 and is adjacent to the LERF vault. See Figure 1.

The GTS has a ceiling-mounted hutch with two lasers that can illuminate the photocathode: a Nd:YLF regenerative amplifier class 3B generating 0.5 mJ, 50 pico-seconds full width of the beam at half its maximum intensity (FWHM) pulses at 532 nm and at 15 Hz repetition rate, and a Coherent 10 Watts (W) CW laser operating at 532 nm wavelength. Only one laser can be utilized at a time to illuminate the photocathode.

In addition to the lasers, the GTS houses a 500 kV, 5 mA DC SF6 (10 PSIG) gas-insulated high voltage power supply.

A cathode solenoid coil for studying magnetized beam has been recently installed between the gun and the beam line, providing a magnetic field of about 1400 Gauss at the photocathode with a maximum operational current of 400 A and operational voltage of 77 V. The magnet power supply is interlocked to the sliding concrete shield door to prevent access to the magnet when it is energized. When personnel are required to work on the magnet while energized, that work will be conducted under a separate OSP, in which all personnel accessing the 600 Gauss area around the magnet will also be trained to remove ferromagnetic objects from themselves including wallet. The magnet is shown in yellow in Figure 2.

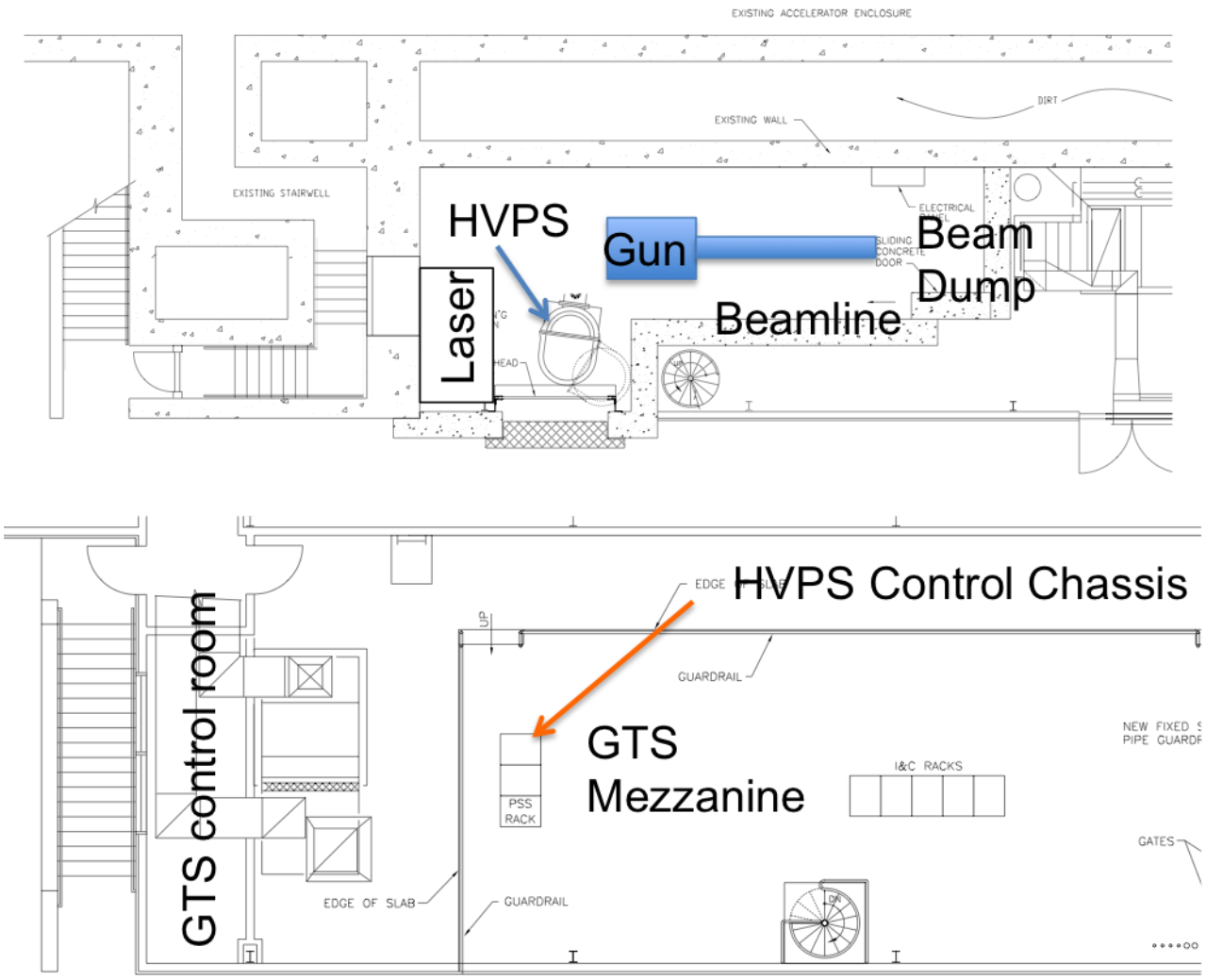


Figure 1. GTS enclosure civil drawing showing the location of the DC photocathode gun, the high voltage power supply (HVPS) and laser hutch.

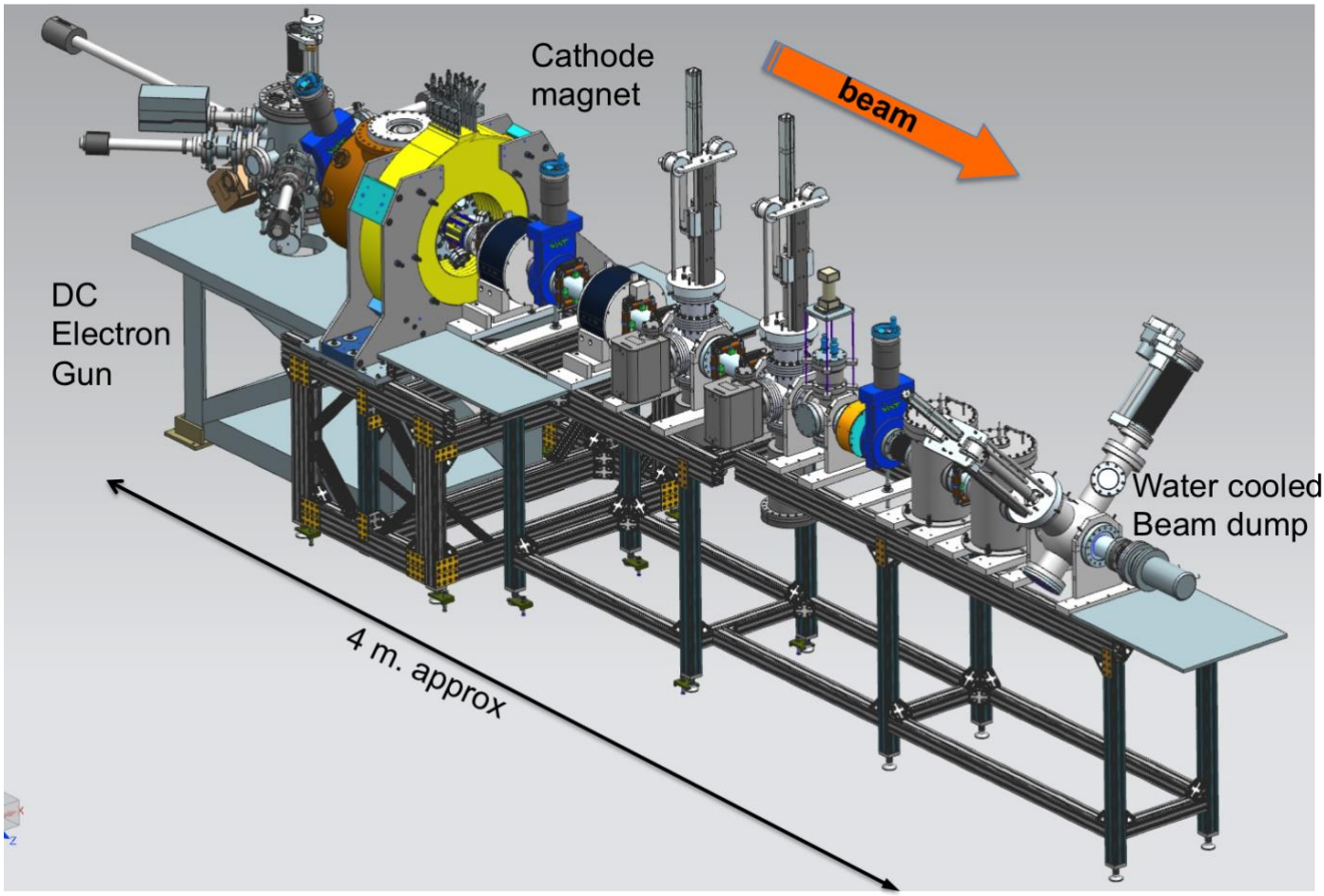


Figure 2. Isometric view sketch of the GTS beam line.

In normal operating conditions, the only access to the GTS enclosure is via the sliding concrete shield door (shown near the beam dump location in Figure 1). Behind the concrete shield door, a sliding steel door is part of the LPSS to block any laser non-ionizing radiation. During installation periods, a metal overhead roll-up door is used for access to move equipment in and out such as the electron gun or the High Voltage Power Supply. The roll-up door is located at the opposite end of the room and is locked from the inside with a chain. This roll-up door IS NOT AN EXIT during normal GTS operating conditions. Concrete shield blocks are placed outside the roll-up door, therefore no access is possible through this door. Since the GTS is the plenum for the LERF vault HVAC, there is a vent between the LERF emergency exit staircase and the GTS (Fig. 1).

ANALYZE THE HAZARDS and IMPLEMENT CONTROLS

4. Hazards identified on written Task Hazard Analysis

- Gun operation / Potential exposure to Ionizing Radiation
- Laser operation / Potential exposure to non-ionizing laser radiation
- Magnet coil operation / Magnetic Field Hazard
- Enclosure occupancy / Potential Oxygen Deficiency Hazard from SF6 or nitrogen accidental release
- Sliding Concrete Shield door operation/ Crushing

- Sliding Concrete Shield door operation/ Trip hazard

5. Authority and Responsibility:

5.1 Who has authority to implement/terminate

Matt Poelker and/or Carlos Hernandez-Garcia.

5.2 Who is responsible for key tasks

Carlos Hernandez-Garcia is responsible for training GTS operators, for ensuring safe operation of the Gun Test Stand (GTS) and for leading the R&D program.

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 – K. Welch
Oxygen Deficiency Hazards – J. Williams
Safety Warden GTS mezzanine & control room – J. Gubeli
Safety Warden GTS lower area (vault/enclosure) – H. Fanning

6. Personal and Environmental Hazard Controls Including:

6.1 Shielding

The prompt ionizing radiation hazard is due to x-ray emission caused by electrons impinging on a material, typically vacuum chambers and beam lines. Normal beam operations will be at 350keV and up to 5 mA DC, the physical limit of the HVPS. However, the physical limit of the power supply is 500 kV.

A series of surveys were conducted in June 2016 around the GTS area while current was generated in the gun and terminated in the beam dump. Surveys were performed with current varying in steps of 100 uA from 100 uA to 980 uA. At each step radiation measurements were performed around the facility, concentrating especially on the penetrations through the roof of the GTS-II enclosure. Detailed results can be found in the survey report at https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-123883/2016_06_17-GTS%20surveys-75072.pdf. The results at 980 uA are included in Figure 3.

It should be noted that the only radiation levels above background were detected a) with CARM probes located inside the GTS enclosure, and b) immediately above the roof penetrations, where levels at waist level did not exceed the RCA limit of 0.05 mrem/h. A close look at signal from CARM probes outside the enclosure, in particular the one near the stairs leading to the exit door on the west side of the building, indicates that no radiation above background was detected. The area above the mezzanine penetrations has been marked as RCA.

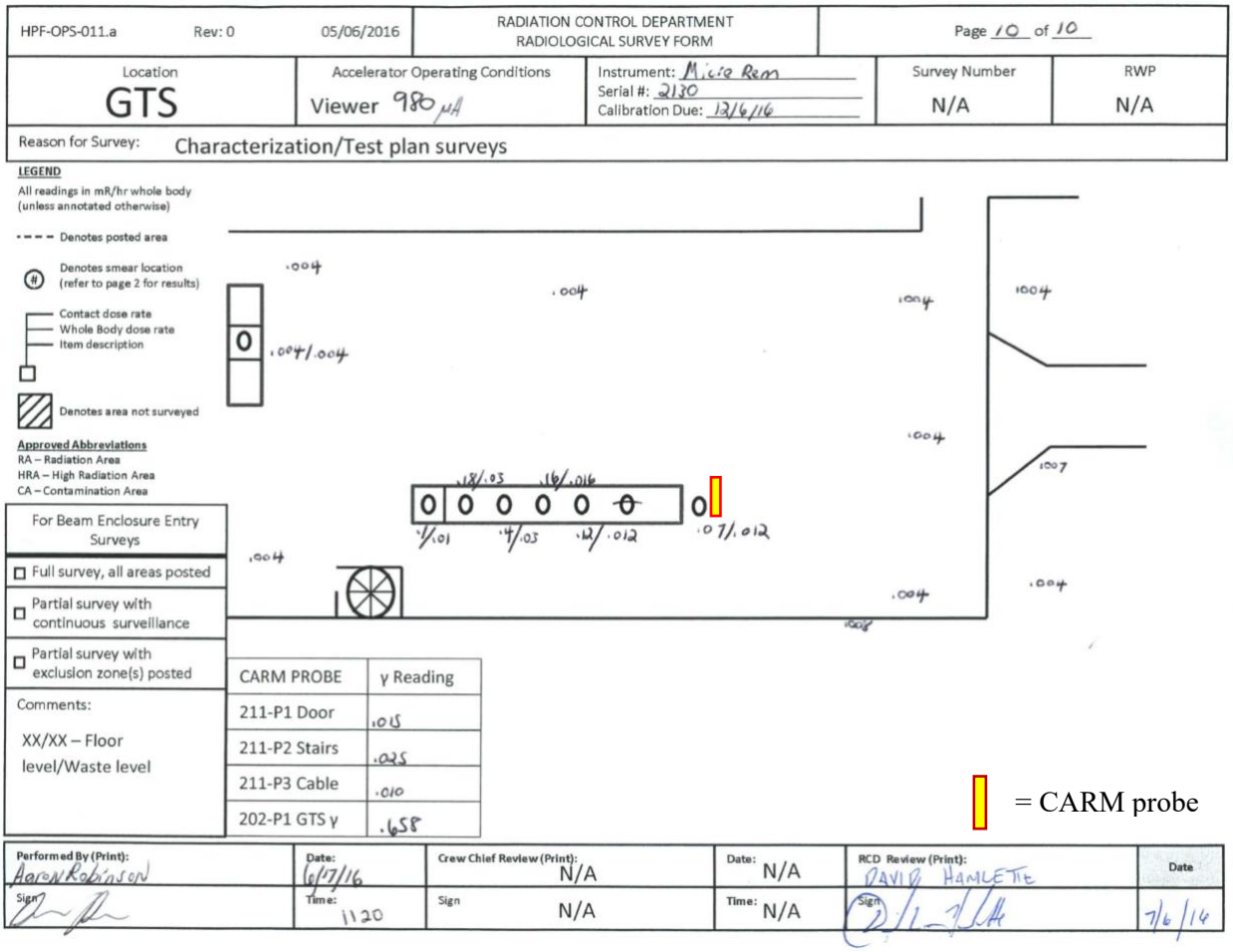


Figure 3. Radiation survey results.

Maximum Credible Accident: The high voltage power supply physical limits are 500 kV at 5 mA. Accidental beam losses at these values will result in loss of vacuum in the beam line, and subsequently in the electron gun where the photocathode emission is severely affected by vacuum conditions, therefore electron emission should cease within one minute. Due to the uncertainty of the source term, we estimate that the total dose accumulated over 2 minutes could be below ~500 mrem per occurrence, which complies with the accident limit scenario, defined as mis-steering or loss of control of the electron beam under conditions corresponding to the upper limit of the beam power possible in a specific area. Under such conditions the integrated equivalent dose per occurrence shall not exceed 15 rem (Shielding Policy for Ionizing Radiation – RCD-POL-14 #001).

Summary: Current shielding of the GTS has been deemed satisfactory and compliant with applicable JLab policies by the Radiation Control Group via surveys performed for currents up to ~1 mA. When all systems become ready to operate beyond 1mA, CIS staff will coordinate with the Radiation Control Department to perform more radiation surveys every time the current is increased beyond that for which radiation surveys were performed. Additional measures (posting and shielding) may be necessary depending on radiation survey results at higher current.

Note: All the shielding is the same as when first installed in Dec 2007.

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

6.3 Interlocks

The Safety Systems Group has written a complete Personal Safety System User Guide (Revision 1.0 January 10 2008) that is part of this OSP. Important PSS information and related sweep procedures taken from that document follow.

The GTS personnel safety system (PSS) is an engineered interlock system to help protect personnel from exposure to prompt ionizing radiation (PIR) that results from operation of the electron gun. The GTS is composed of a concrete enclosure (vault) Room 109A, and a control room above the enclosure in the mezzanine Room 217 (Fig. 1). There are two personnel doors, a sliding concrete door and a sliding steel door. A rollup over-head door is only used for loading large pieces of equipment. This door is interlocked and is blocked by concrete shield blocks during operations. See Figure 4.

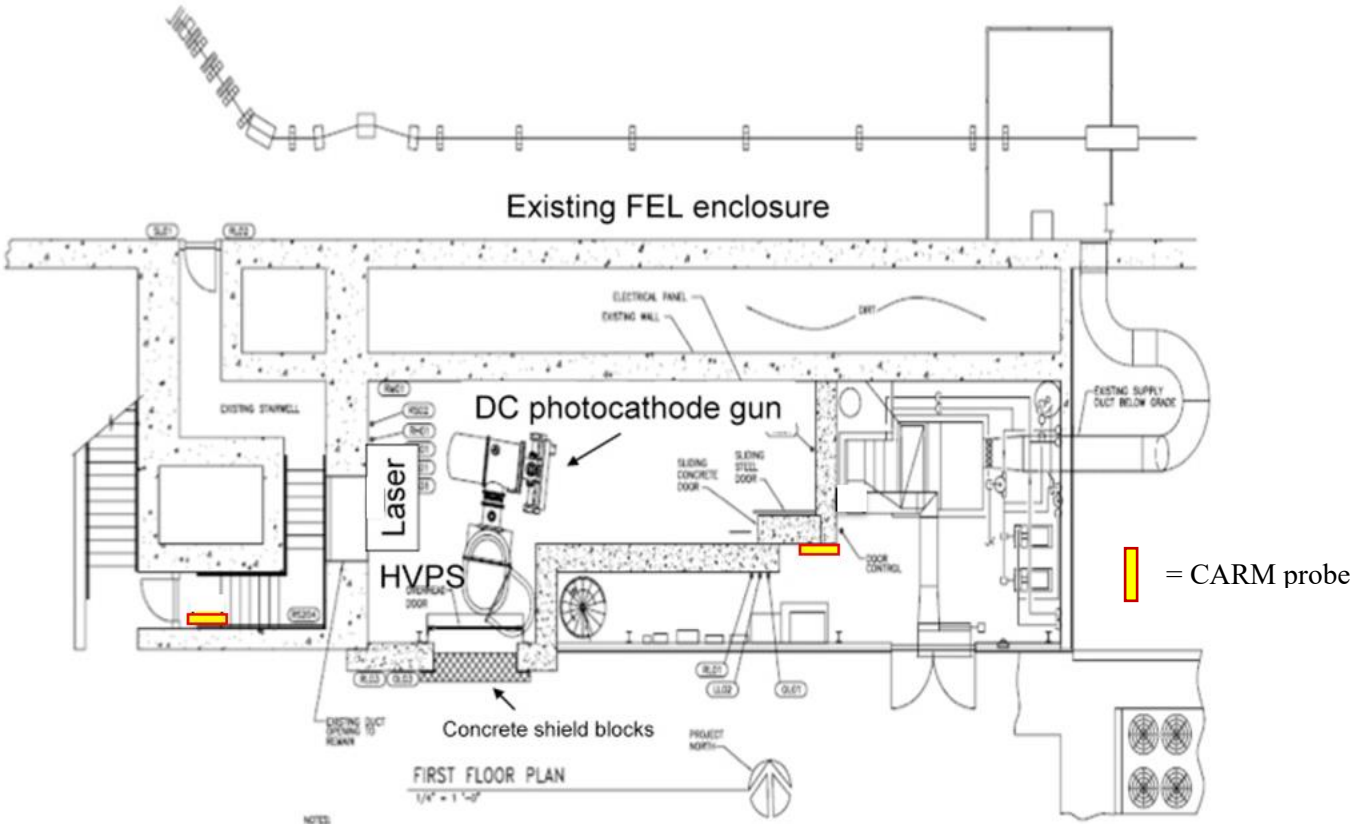


Figure 4. GTS enclosure civil layout showing the locations of doors and major pieces of equipment. The yellow rectangles indicate positions of the gamma probes. An additional gamma probe is located above the penetration in the mezzanine shown in figure 3

Figure 5 shows the concrete sliding door and the steel sliding door.

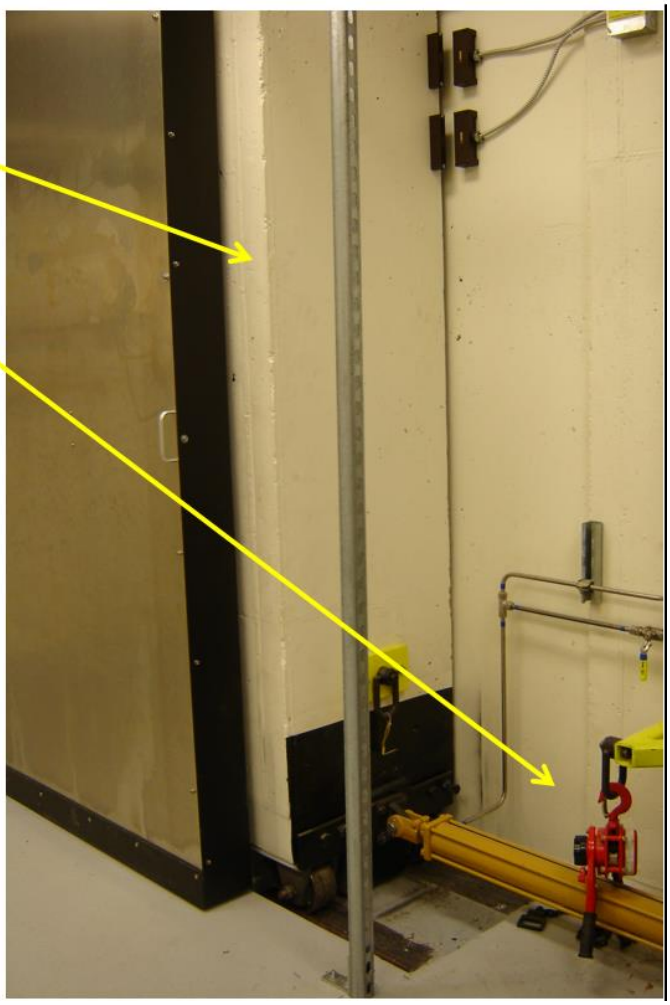


Figure 5. Detail showing the sliding concrete door and the sliding steel door from within the GTS enclosure.

The PSS is interlocked to the gun High Voltage Power Supply (HVPS) and to the Drive Laser Power Unit. It is the function of the PSS logic to determine the status of the GTS enclosure and, if a fault is detected, both the gun HVPS and the laser power unit are de-energized.

The cathode magnet is interlocked to the sliding concrete door interlock preventing access to the GTS enclosure when the magnet is energized. However, there will be a sliding concrete door interlock bypass key to be able to enter GTS with the magnet ON for specific measurements and studies. When the sliding concrete door interlock is bypassed, to prevent personnel with surgical implants and bioelectric devices from entering the 5 Gauss boundary, strobe light indicators are installed on the top of power supply and at the access sliding concrete door to show that the solenoid is energized. In addition, flashing red beacons and personnel barricades are installed at the actual 5 Gauss contour. A 5 Gauss boundary sign is posted at the GTS by the sliding concrete door entrance and a 600 Gauss boundary is posted near the solenoid.

An interlock between the nitrogen source and the air-handling unit has been installed and is operational as an engineered control. The interlock is a fail-closed solenoid valve up-stream of the nitrogen manifold and mounted outside of the GTS enclosure that closes when the air handing unit is not off.

6.4 Monitoring systems

The GTS enclosure has one Radiation Alarming Monitor (CARM) connected to the LERF radiation monitoring system to alert personnel working in the GTS enclosure in the event of LERF electron beam loss (one gamma probe is located behind the laser table attached to the air vent, one neutron probe is located also inside the GTS to one side of the laser table in the upper-left corner).

The GTS enclosure has its own CARM radiation monitoring system consisting of one gamma probe located next to the concrete shield door controls outside the enclosure, another gamma probe located in the LERF exit staircase, and a third gamma probes located in the GTS mezzanine adjacent to a cable penetration (Fig. 3).
ODH sensors are inside the GTS enclosure, in the rear stair well, and at collection points in the LERF vault.

The Safety System Group electronics continuously monitor the ODH sensor.

6.5 Ventilation

The GTS enclosure is part of the air conditioning system of the LERF vault. When the air conditioning system is operational, any SF_6 leak off the high voltage power supply would be quickly dispersed due to the high flow rate of the air conditioning system. When the air conditioning system is off, any SF_6 would drain out of the GTS vault through the air conditioning recovery port and into the rear stair well of the LERF vault and then into the LERF vault.

The GTS enclosure is designed as an ODH 0 area.

The ODH assessment is addressed under a separate document ***JLAB-TN-07-082*** and also in the high voltage power supply OSP Complex LOTO ***ACC-22-144152-LTTI***. The floor area of room 109A was measured as 606.5 square feet with a 10-foot ceiling (6065 cubic feet). At one end of the room is an intake duct to the air-handling unit that supplies heated or cooled air mixed with fresh air to the LERF accelerator room. At the other end of the room is a hole in the wall that is open to the accelerator room and is covered with steel screen. Therefore, the GTS enclosure room 109A is considered a plenum. There is one roll up door, normally closed, and a concrete door, normally open. The concrete doorway has plastic panels to eliminate airflow through the doorway. In accordance with Appendix 6500-T3, reliable ventilation may be considered a relevant factor in this ODH assessment if the volume of air in the room is replaced with fresh air at a minimum of once an hour. The ventilation for this room comes from an air-handling unit. This unit operates 24 hours a day and 7 days a week. Because this room is a plenum, the air changes are larger than 50 air changes an hour.

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

The following hazards are detailed in attached Task Hazard Analysis.

- ODH
- Magnetic DC fields
- Exposure to ionizing radiation
- Exposure to non-ionizing (laser) radiation
- Potential to crushing of limbs by operation of the concrete shield door.
- Potential to tripping off while stepping over the concrete shield door trench.

Laser safety goggles are located next to the PSS/LPSS console in the GTS control room 217.
Inside the GTS enclosure, the PPE cabinet contains leather gloves and safety glasses.

7. List of Safety Equipment:

7.1 List of Safety Equipment:

- Safety glasses located in the PPE cabinet
- Working leather and fabric gloves located in the PPE cabinet
- Laser safety googles are located in the GTS mezzanine by the PSS console. This topic is covered in a different LSOP

7.2 Special Tools:

A grounding stick is attached to the high voltage power supply tank in the GTS enclosure. Ground sticks are required when disconnecting the high voltage cable from the gun or from the HVPS. LOTO personal lock(s), labels and a hasp to be used in the HVPS disconnect are located inside a toolbox just below the HVPS disconnect in the GTS mezzanine room 217. These activities are covered under the GTS 500kV HVPS OSP, and are not part of normal GTS operations.

8. Associated Administrative Controls

The configuration of the gun and laser systems is highly dependent on administrative procedures and configuration control. There are several assumptions concerning HVPS system configuration that form part of this logic.

- Safety Systems Group staff is responsible for:
  - LPSS engineered controls
  - PSS administrative and engineered controls

- Center for Injectors and Sources (CIS) staff is responsible for:
  - LPSS administrative controls
  - SF_6 Gas insulated HVPS administrative and engineered controls
  - Cathode magnet administrative and engineered controls

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

- CIS GTS personnel are responsible for safe operation of the GTS facility. This includes limiting beam power to fall within the identified operations and safety parameters.
- LERF vault PSS logic manages the LERF exit labyrinth door switches and Run/Safe Box 204 to provide an “Area Secure” signal to the GTS PSS logic
- The GTS enclosure is currently rated ODH 0
  - Since SF6 is heavier than air, one active ODH sensor is installed under the HVPS tank and will set the off the alarm in the event of SF6 leakage
- The Glassman HVPS control unit is interlocked to the PSS, it cannot be energized unless the PSS is in “Run” mode, attained after the GTS enclosure has been swept.
- The cathode magnet is interlocked to the sliding concrete door interlock preventing access to the GTS enclosure when the magnet is energized but is not part of the PSS.
- The laser power unit in interlocked to the GTS PSS/LPSS.
- The CARMs/radiation probes are interlocked to the PSS.
- Fixed and removable shielding - i.e. concrete and steel walls, doors, vents and blocks - are adequate to meet all safety requirements that are not protected by functions of the PSS or LPSS.
- The door/gate in the LERF vault leading to the west side labyrinth exit is interlocked to the PSS. This is the area where the run safe box # 204 is located, and shared by the LERF PSS and the GTS PSS.

9. Training

9.1 What are the Training Requirements (See List of Training Skills)

For safe operations of any of those systems, GTS operators must receive the following training:.

- The concrete shield door operation is part of this OSP.
- The PSS/LPSS user manual is part of this OSP. The Safety Systems Group in coordination with the CIS group keeps its certification up-to-date.
- The Laser system is covered under a separate document ***ACC-21-120940-LOSP***.
- The High Voltage Power Supply is covered in a separate document ***ACC-22-144152-LTTI***
- The cathode magnet coil is covered under a separate OSP ***ACC-20-107399-OSP.***
- Training on operational procedures for the DC photocathode gun and for Drive Laser will be given by Carlos Hernandez-Garcia and/or M.A. Mamun (gun) and Shukui Zhang (laser) to personnel participating in GTS studies and experiment on as-needed basis.
- SAF100 ES&H Orientation
- SAF103 Oxygen Deficiency Hazard
- SAF143kd LERF Safety Awareness
- SAF801 Radiation Worker Training
- This document

DEVELOP THE PROCEDURE

10. Operating Guidelines

The GTS 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 GTS can produce only local work area impacts.

Staffing

The GTS can be operated by either a single trained and authorized user (typically the personnel conducting gun and/or beam studies), or in multiple unattended shifts. See:
Final Safety Assessment Document Rev 8c: https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-21395

GTS Operation

Prior to beam operation, the GTS must be placed in a personnel safe mode using the Personnel Safety System (PSS) and/or the Laser Personnel Safety System (LPSS). These involve using the proper door configuration, sweep and mode procedures, and securing of the GTS test cave and LERF exit staircase area described later in this document. Once the GTS PSS is in "Run" mode, the operator uses computer terminals in the GTS control room to generate and monitor electron beam.

GTS Operator Requirements

Additionally to the training listed in section 9, the GTS operator must:

1. Read and understand this OSP that includes PSS sweep procedures,
2. Receive the practical training on this OSP and on Gun operational procedures from system owner (Carlos Hernandez-Garcia) or designee and,
3. Perform walkthrough of the following areas: GTS control room, mezzanine, spiral staircase, and enclosure.

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

Safety: GTS control room and mezzanine Safety Warden, J. Gubeli x7862, GTS vault H. Fanning x7619
GTS system owner: Carlos Hernandez-Garcia, office 269-6862, cel. 757-926-9133
ODH, Fire: CEBAF Crew Chief: 269-7045, cel. 757-630-7050.
Emergency: Guard gate 269-5822

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

The GTS enclosure can operate in two modes: a) Laser Alignment and b) Run mode. Laser Alignment mode is utilized for laser work only and no high voltage operations are permitted by LPSS/PSS. The enclosure is shielded from non-ionizing laser radiation to the outside by a sliding steel door interlocked to the LPSS/PSS. In case of emergency, this door can be manually slide open form the inside or outside. If the door is opened while in Laser Alignment mode permit, it will crash the LPSS and therefore close laser shutters and cut power to the laser.

In Run mode, the PSS gives "Gun Permit" which allows high voltage operations and Laser operations. A sliding concrete door in front of the steel sliding door shields the outside of the enclosure from prompt ionizing radiation during high voltage and beam operations. Procedures to operate the sliding concrete shield door are described at the end of this section.

The PSS/LPSS console is located in the GTS control room. Figure 6 shows a picture of the console (left), and a picture of the PSS/LPSS rack in the GTS Mezzanine (right).

Figure 6. Left, the PSS console is located in the GTS control room. Right, the PSS rack is located in the GTS mezzanine alongside racks housing IOCs, controls and monitoring equipment.

SSI Status

The Safety System Interface (SSI) status lamps display the active permits to the Gun, Drive Laser, and future RF systems.
"Gun Permit" will light when the gun HVPS has a PSS permit.
"Laser Permit" will light when the Drive Laser shutters receive a permit from the LPSS.

Door Status

The Door Status lamps in the PSS console indicate the important positions of the doors.
The sliding concrete door is the standard personnel door.
Note: this door will automatically open when any PSS/LPSS crash switch is pushed.
The sliding steel door is used to minimize laser light emanating from the enclosure during Laser Alignment mode. *This door must also be closed during and after a PSS sweep, as it is interlocked to this system.*
The roll-up door is only used to install large pieces of equipment. See figures.

The LERF exit staircase door in the west side of the LERF vault in interlocked to the GTS PSS. It is normally closed but can be pushed open in case of emergency. When pushed open, it will crash the GTS PSS. Figure 7 shows a picture of the LERF exit staircase door. The green beacon flashes once the Run/Safe box # 204 in the staircase has been armed.

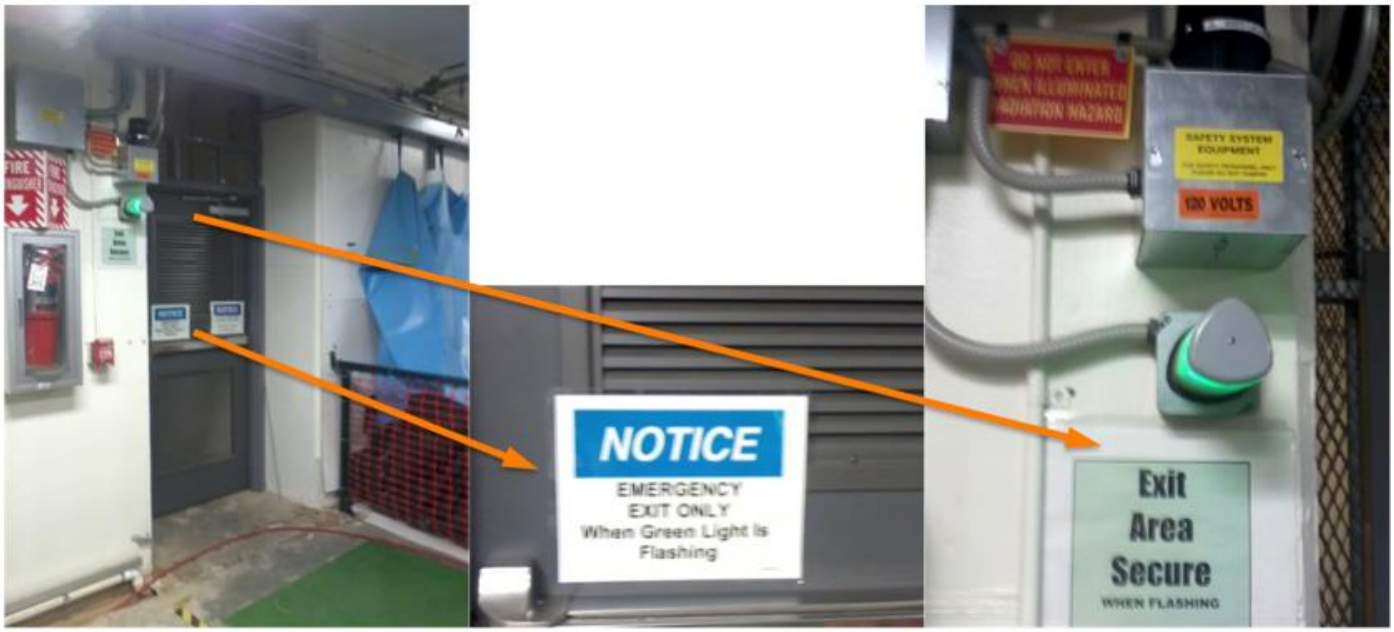


Figure 7. Picture of the LERF exit staircase door located in the west side of the LERF vault (next to the SF6 blue bladder).

Keyswitch Controls

The keyswitch controls are used to change the state of the PSS and LPSS operating modes and reset non-access control faults. See Figure 6, left.

The colored LEDs indicate the status of the PSS operating mode. For the PSS there are two keyswitches and one key used in the operation of the GTS. The left hand keyswitch is used to switch between OPEN mode and SWEEP mode. The key can only be removed when in the "Sweep" position. The same key is used for the sweep so that the GTS cannot be accidentally switched to RUN while a sweep team is in the test cave. When a sweep is completed the key must be returned to the right hand key switch and used to set the operating mode to RUN.
If a non-access control fault occurs, such as a radiation monitor trip, the key must be cycled from RUN to SWEEP then back to RUN in order to reset the PSS system.
Note: Switching the keyswitch from Sweep to RUN starts a timer. The gun HVPS and Laser shutters may not be operated until the timer has reached 30 seconds.

For LPSS Laser Alignment there are two keyswitches with a shared key. The keyswitch on the panel is used to switch between RUN mode and ALIGNMENT mode. The key can only be removed when in the "Alignment" position. The same key is used in the Laser permit status box in the cave so that the GTS cannot be accidentally switched to RUN while laser qualified staff are performing tests. The keyswitch in the cave is used to switch the shutter permits to ALIGNMENT mode. When testing is complete, the key is returned to the control room panel keyswitch and used to set the operating mode to RUN.
Note: Switching the cave keyswitch to ALIGNMENT starts a timer. The Laser shutters will not operate until the timer has reached 30 seconds.

Safety Crash

The Safety Crash is used to shutdown all GTS systems in an emergency.

This crash switch will remove permits to all high voltage power sources and the laser shutters. It will also crash the sweep and force the concrete door to open.

Door Configurations

Gun Operations

In this mode, the sliding concrete door, the sliding steel door, the roll-up door and the LERF exit staircase door must be closed completely.

Laser Alignment Operations

In this mode the sliding concrete door must be fully open, the sliding steel door, the roll-up door and the LERF exit staircase must be closed completely.

PSS Operational Modes

Pre-operational Checks:
In order to avoid having to re-sweep, the following preoperational checks should be made:

- Confirm that the LERF exit staircase located in the west side of the LERF vault is secure.
- Door operation
    - Check that the roll-up door is closed
    - Check that there are no obstacles blocking the moving concrete and sliding steel doors

Open Mode

Open mode is the default state for the PSS. In this mode all Run/Safe boxes are not armed and the gun HVPS and laser shutter permits are OFF. This mode can be reached by turning the sweep keyswitch to OPEN or by pushing any PSS/LPSS crash switch.

Conditions:

- No Gun HVPS permitted
- Laser Power Supply permitted when Class 1 enclosure is secure
- Roll-up door may be open
- LERF exit staircase area can be in any state

Note: The sliding concrete door must be fully open to meet other safety requirements.

- **Sweep Mode**

Prior to beginning operations, the GTS enclosure and the LERF exit staircase must be searched to ensure all personnel leaves those areas.

*Note: See **Section 8.0** of this user's guide for instructions that describe the proper sweep procedures and patterns.*

Conditions:

- No Gun HVPS permitted
- Laser Power Supply permitted when Class 1 enclosure is secure
- Roll-up door must be closed

- LERF exit staircase door must be closed to arm Run/Safe box #204. This area must be swept and the Run/Safe box armed BEFORE sweeping the GTS enclosure
- Sliding steel door must be fully closed before, during, and after sweep
- Sliding concrete door must be fully open before and during sweep, and fully closed when sweep is complete

- **Ready Mode**

"Ready Mode" is an internal PSS mode. It serves as a mode that the PSS will drop to when there is a non-access control fault, such as a radiation monitor.

- **Run Mode**

In order to enter and remain in RUN mode, all PSS interlocks must be OK.

Conditions:
- LERF exit staircase area swept and Run/Safe box #204 armed
- GTS enclosure must be swept and secured
- Sliding concrete door closed
- Sliding steel door closed
- Roll-up door closed
- Crash buttons active
- Audible warnings (for 30 seconds)
- Visible warnings (continuous)
- PSS shutters open (30 second delay)
- CARMs active
- Sweep Key in RUN position
- Laser Alignment Key in RUN position (Run Mode excludes Laser Alignment mode)
- Gun HVPS permitted (30 second delay)
- Laser Power Unit permitted

Note: If a CARM trips the PSS, turn the key from RUN back to Sweep, then back to RUN in order to reset the fault.

What happens if someone is in the test cave when it is switched to RUN Mode? The concrete sliding door cannot physically be closed from the inside, ensuring that no personnel is inside the GTS enclosure when the PSS interlocks acknowledge concrete sliding door as closed.
- In the LERF exit staircase and in the GTS enclosure the Run/Safe box lamps switch to "Unsafe"
- An alarm klaxon sounds for 30 seconds before the gun is enabled.
- Personnel should immediately exit the enclosure by hitting the nearest crash switch to open the sliding concrete door.

- **Returning to Open Mode**

- Turn off the gun HVPS
- Switch the PSS key to "Sweep" mode
- Remove key and insert in left hand key switch
- Switch the PSS to "OPEN" mode

- **LPSS Operational Modes**

Pre-operational Checks:

- The LERF Exit staircase may be open.
- Door operation
  - Check that the roll-up door is closed
  - Check that there are no obstacles blocking the sliding steel door
  - Moving concrete door must be fully open to meet personnel safety requirements

- **Open Mode**

Open mode is the default state for the LPSS. This mode can be reached by turning the PSS sweep keyswitch to OPEN or by pushing any PSS/LPSS crash switch.

Conditions:

- No Gun HVPS permitted
- Laser Power Supply permitted when Class 1 enclosure is secure
- Roll-up door may be open
- LERF Exit staircase may be open

- **Laser Alignment Mode**

In order to enter and remain in Laser Alignment mode, all LPSS interlocks must be OK

Conditions:

- PSS Keyswitch is in the "OPEN" position
- Sliding concrete door must be fully open
- Roll-up door must be closed
- Sliding steel door must be closed
- PSS shutters open (30 sec. delay)
- Audible warnings (for 30 seconds)
- Visible warnings (continuous)
- Crash buttons active
- Administrative "sweep" of room
- Laser Alignment Keyswitch set (Laser Alignment Mode excludes Run mode)
- No Gun HVPS permitted
- Laser Power Supply permitted
- Class 4 laser operations permitted with proper LPE

- **Returning to Open Mode**

- If open, close the covers of the laser hutch
- Turn the Laser keyswitch in the cave counter-clockwise and remove
- Open the sliding steel door
- Return to the control room
- Insert the Laser keyswitch and turn clockwise to "RUN" mode to allow for gun operations

Sweep Procedures

General Duties of the Sweep Team

Prior to sweeping, the sweepers must go to the GTS enclosure and ask personnel to leave the enclosure. In addition, the presence of the cathode magnet now requires an additional pre-sweep check: The strong magnetic field will attract loose ferromagnetic objects, possibly injuring body parts or striking fragile components. Prior to energizing the magnet, a sweep of cordoned area around the magnet will be performed for any loose magnetic objects such as tools, bolts, etc. All personnel accessing the 600 Gauss area around the magnet will also be trained to remove ferromagnetic objects from themselves including wallet.

Afterwards, the sweepers should ensure that all of the appropriate doors are closed. Confirm that the PSS panel or screens indicates that the doors are closed and the PSS panel LEDs read "Sweep Mode" for both system A and B.

It is the duty of the sweep team to thoroughly search the GTS enclosure for personnel. During the sweep, the team members must assume that there may be personnel who did not hear announcements or are incapacitated.

The sweepers should not perform any other tasks when doing an area sweep. Once the sweep starts, a 2-minute timer also starts. If the sweep is not completed within 2 minutes, the sweep will drop and will have to be re-swept.

At least one of the sweepers shall be a qualified lead sweeper. This is someone who is familiar with the sweep procedures for the GTS and for the LERF, and has swept the area at least once.

If anyone is found in the enclosure during a sweep, the person(s) must accompany the sweep team throughout the rest of the sweep.

GTS Sweep Procedure for Gun Operations

Identify two qualified personnel as the sweep team.

Walk through the GTS enclosure

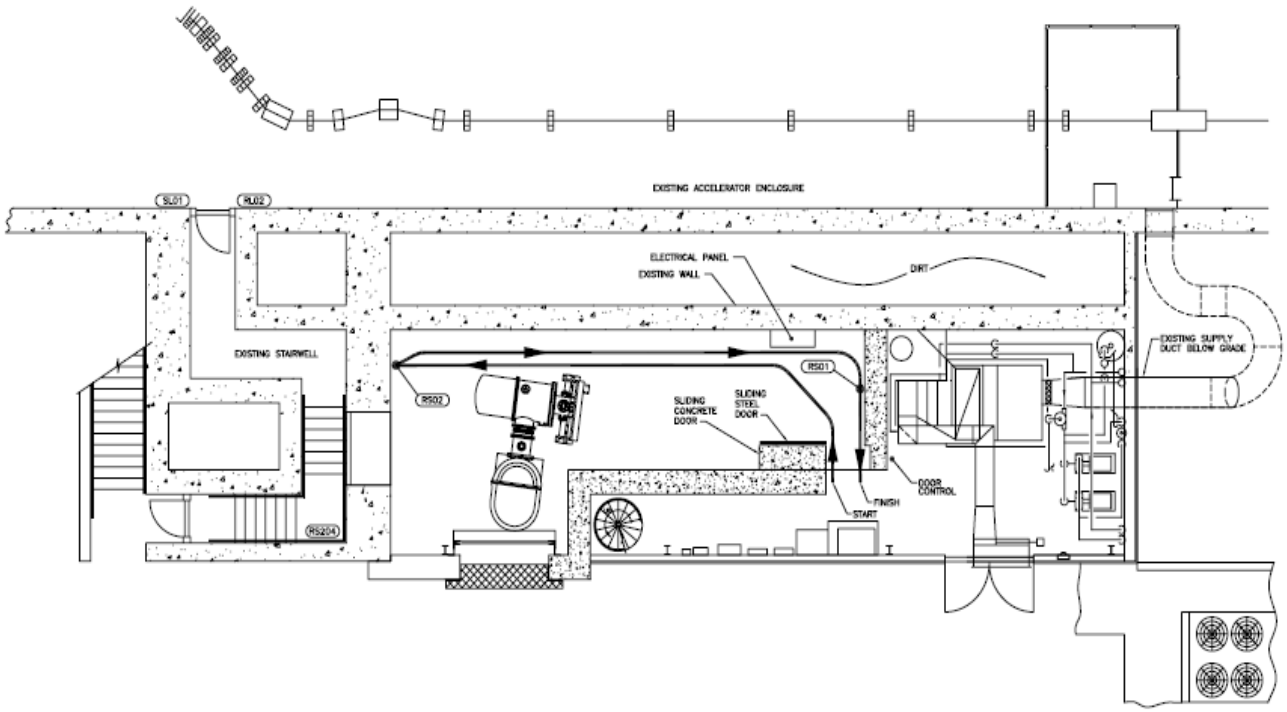
- Ask any personnel in the cave to leave immediately
- Confirm that the roll-up door is closed
- Confirm that no magnetic objects are laying in the cordoned area around the cathode magnet
- Confirm that the sliding concrete door is fully open
- Return to the control room ensuring that the slide steel door is fully closed
- Look at the PSS console
    - Verify that the doors indicates their proper positions
    - Verify that the all system permits are OFF
    - Verify that the LERF exit staircase lamp is ON. If not, proceed to sweeping this area (see LERF exit staircase area sweep procedure below).

- Switch the PSS left hand keyswitch to Sweep mode and remove the sweep key
    - Verify that the PSS changes to Sweep mode
    - Take a copy of the sweep map if desired

Two sweepers exit the control room area. One is posted at the entrance of the test cave while the other enters through the concrete door.

- Open the sliding steel door, enter the GTS enclosure and close the sliding steel door behind you ensuring it closes completely
- Do a search for any personnel
- Arm the first Run/Safe box on the west wall to the right of the plenum vent
  - Verify that the Yellow "Operational" indicator is lit
- Arm the second Run/Safe box on the east wall near the exit
  - Verify that the Yellow "Operational" indicator is lit
- Turn the lights off, the switch is near the exit
- Exit the test enclosure ensuring the sliding steel door is fully closed upon exiting
- Close the sliding concrete door using the push buttons located next to the door on the right hand side. It must close within 60 seconds in order to maintain the sweep
- Return to the control room
- Place the sweep key in the right hand keyswitch and switch it to "Run" mode to begin operations

Note: Once the sweep is complete, the sweepers have exited the test cave and closed the concrete door, the PSS will automatically go to "Ready" mode.



FEL GTS SWEEP DIAGRAM

GTS Sweep Procedure for Laser Alignment

Note: The detailed Sweep requirements for Laser Alignment mode are explained in the GTS LSOP.

LERF exit staircase area must be secured prior to start of GTS cave sweep.

Walk through the GTS enclosure

- Ask any personnel in the enclosure to leave
- Confirm that the roll-up door is closed
- Confirm that the concrete door is fully open
- Ensure that the sliding steel door is closed behind you

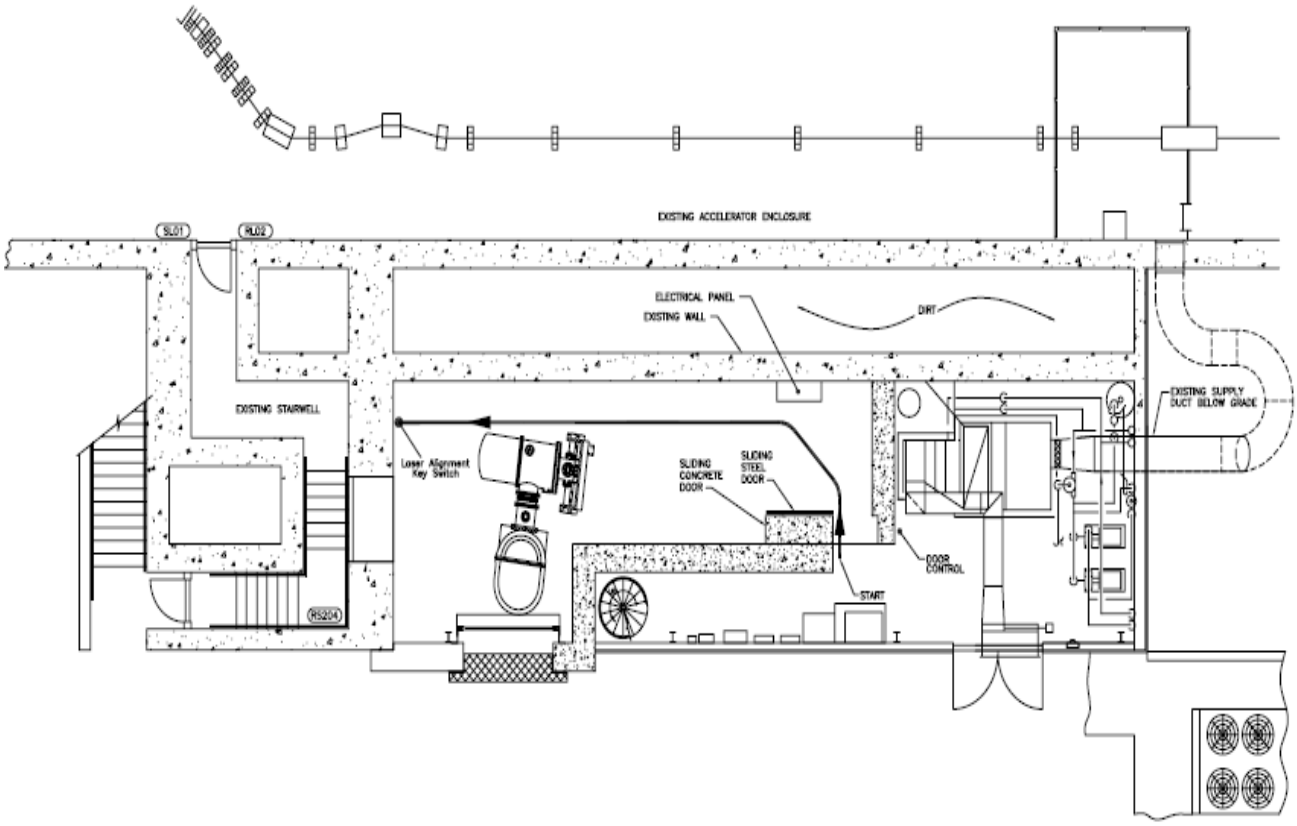
Return to the control room

- Look at the PSS panel.
    - Verify that the doors indicates their proper positions
    - Verify that the all system permits are OFF

- Switch the Laser keyswitch to Alignment mode and remove the key

The sweeper exits the control room area and enters the GTS enclosure. The sliding concrete door remains open at all times. The steel sliding door is closed during laser alignment mode

- Open the sliding steel door and close it behind you after entering the enclosure
- Check for any remaining personnel, if found ask them to leave
- Use appropriate LPE
- Insert the key into Laser permit status box in the cave and turn it clockwise to the “Alignment” position to begin tests
    - The Laser warning horn on the Laser permit status box in the cave will sound for 30 seconds
    - Once the 30 second timer is complete, the LPSS will provide a "Shutter Permit"
    - The yellow strobe outside the door will start flash
    - The yellow lamp on the Laser permit status box in the cave will light
    - The LPSS will automatically open the laser shutters



FEL GTS ALIGNMENT SWEEP DIAGRAM

LERF-exit staircase Area Sweep Procedure

LERF exit staircase area must be secured prior to sweeping the GTS enclosure.

Identify two qualified personnel as the sweep team.

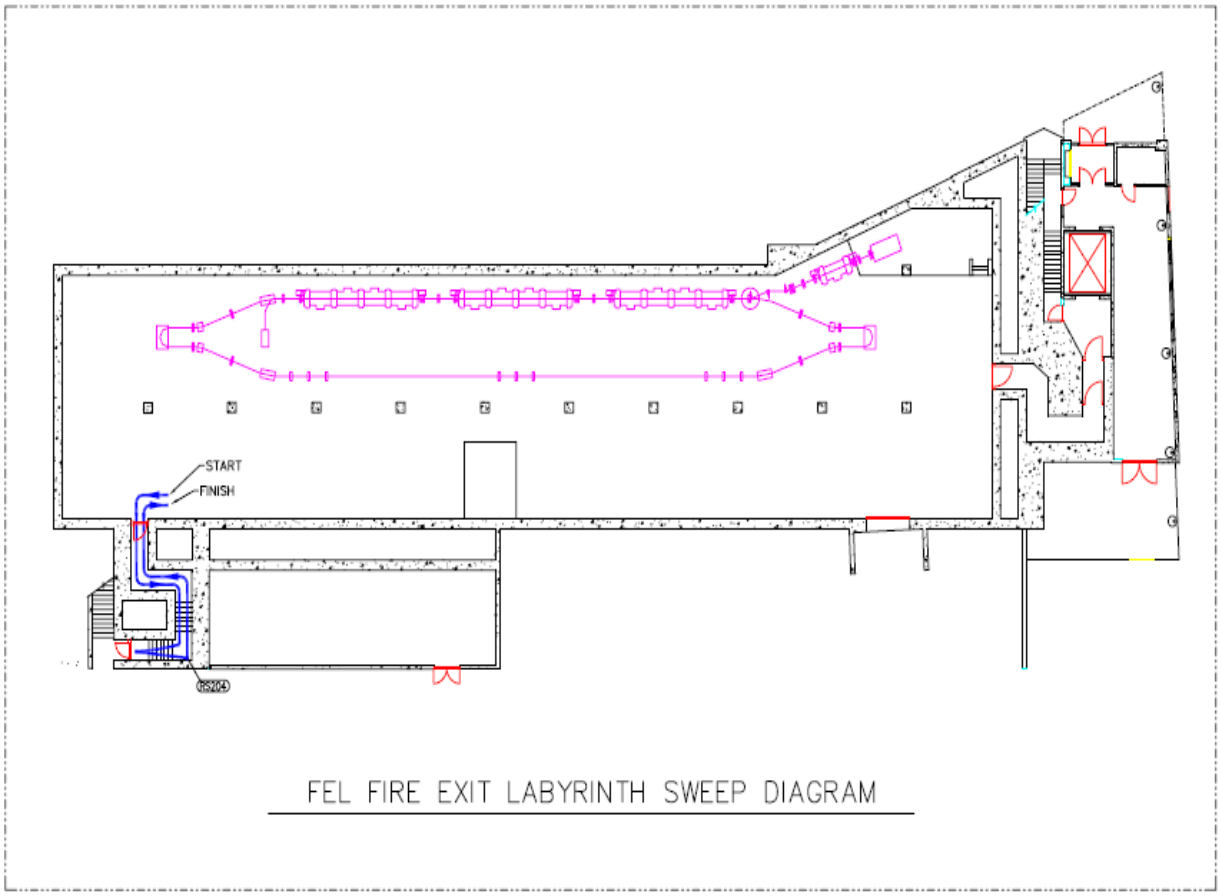
- Go to the MCC and request/access the special sweep key from the Keywatcher panel
- Look at the LERF screen on the PSS computer.
  - Verify that the exit area doors are closed

Two sweepers enter the LERF vault. One is posted at the entrance of the exit staircase while the other enters through the wire door, see figure 7.

- Close the wire door behind you
- Go to the fire door and confirm that it is completely closed and locked
- Arm the Run/Safe box (RS204) on the south wall
  - Verify that the Yellow “Operational” indicator is lit
- Exit the area closing the wire door completely upon exiting
- Check that the "Area Secure" light on the wall outside of the door is lit

- Return to the key to the MCC Keywatcher panel

Note: Once the sweep is complete, the PSS will send an "area secure" signal to both the FEL and GTS.



Concrete sliding door normal operating procedures:

To Close sliding concrete door: -

a. Remove the trench plate using plate-pulling tool. The plate-pulling plate is on a hook affixed to the wall inside the GTS enclosure next to the sliding door.
b. Press door close button and keep it held in for the door to move. There will be a few seconds delay before the door starts to move due to the pre-set time delay switch to allow pump to come up to speed. The door will stop moving when it reaches the limit switch, at this point the close button can be released. **A red flashing light with a high volume buzzer will go off each time the door is actuated.**
c. Monitor the space between the door and the jam to ensure that no one enters while the door is in motion. The door will move slowly, it will take approximately 45 seconds for the door to travel from the fully open to closed.

To Open sliding concrete door: -

a. Press open button and keep it pressed for the door to move, there will be a few seconds delay before the door starts to move due to the pre-set time delay switch to allow pump to come up to speed. The

door will stop moving when it reaches the limit switch, at this point the open button can be released. **A red flashing light with a high volume buzzer will go off each time the door is actuated.**

b. Once to door is fully open, set the trench cover plate in the trench to prevent tripping.

Note: - The control buttons must be kept depressed to move the door. When the door reaches the open or close limit switches, it will stop moving and the button can be released. It is necessary for the door to reach the limit switch in open or close position to activate the PSS interlocks.

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

At any time during GTS operations, the PSS can be brought to OPEN or safe mode, in case there is a need for accessing the enclosure or to conclude high voltage operations. In case of emergency, the crash button in any of the two RUN/SAFE boxes in the GTS enclosure can be depressed. There is also a crash button in the PSS console in the GTS control room.

Returning the PSS to Open Mode in normal operating conditions

- Turn off the gun HVPS from the EPICS control screen
- Proceed to the PSS console and switch the key to "Sweep" mode
- Remove key and insert in left hand key switch
- Switch the key to "OPEN" mode
- Proceed to the GTS enclosure entrance and open the sliding concrete door following procedure described above.

14. Special environmental control requirements:

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

SF6 (Sulfur hexafluoride gas)

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

SF6 is used as an electrical insulating gas inside the pressurized (10 psi) high voltage power supply. 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. See High Voltage Power Supply ***ACC-22-144152-LTTI*** for details on gas transferring operations. SF6 is a powerful greenhouse gas, 23,900 times worse than CO2.

14.3 Abatement steps (secondary containment or special packaging requirements)

To prevent the escape of this gas we have installed a SF6 recovery system. This system passes the gas back and forth between a flexible storage bag, located outside, and the high voltage power supply. The system is also equipped with a vacuum pump to ensure near complete SF6 gas recovery. The system and its operation is described in the GTS HVPS OSP ***ACC-22-144152-LTTI.***

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

In the event of injury, or an immediate emergency exists, call **911** and also notify:

- Guards (**x5822**)
- Occupational Medicine (**x7539**)
- Crew Chief (**x7045**) (if inside the fence)

In case of an injury follow standard JLAB procedures. Initial response cards are located with each phone for appropriate emergency phone numbers. Additional information can be found at https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-24400/*.pdf.

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 and will close the laser shutter if those systems are operational. It will also crash the sweep and will force open the sliding concrete shield door.

Since ionizing radiation is present in the enclosure only when the gun is at high voltage, depressing any of the PSS Safety Crash buttons will restore the area to a safe level.

The following is a list of currently installed alarms:

1. ODH (blue strobe + buzzer)
2. Fire (white strobe + high pitch)

The expected response to any of the alarms is to evacuate the GTS enclosure immediately, proceed to LERF muster point located at the LERF front door, and notify the crew chief.

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

1. ODH cleared by MCC Crew Chief
2. Fire cleared by Facilities Management

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 GTS enclosure AND sliding concrete door closed. **NOTE: This event should never occur if proper sweep procedures are followed.** Expected response is to proceed to the sliding concrete door exit and press the crash button. This will open the door.

c) Electrical Power failure AND sliding concrete door closed. **NOTE: This event should never occur if proper sweep procedures are followed.** In case of power failure and personnel trapped inside GTS with the concrete shield door closed:

1. Proceed to the sliding door and open the two manual hydraulic by-pass valves located on the wall behind the ram and shown in the figure below

2. Attach the big red winch hook to the pull point on the door edge.
3. Set chain winch to lift and operate lever to tighten the chain. This will pull the door open. **NOTE:** It should not take a great deal of force to open the door.
4. If excessive force is required on the chain hoist lever: a) Set the hoist to lower, b) Release the chain tension, c) Check to ensure the manual by-pass valves are open, d) Re-try opening door. If still excessive force is needed call the Guard Gate at 269-5822 for help.

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

ODH heads are maintained and continuously monitored by the Safety Systems Group.
CARMS are maintained by the Radiation Control group.
Both groups are responsible for calibrations and maintenance of their systems.

17. Inspection Schedules

PSS certifications are performed twice a year by the Safety Systems Group in coordination with CIS personnel.

18. References/Associated/Relevant Documentation

- Laser ***ACC-21-120940-LOSP***
- High Voltage Power Supply ***ACC-22-144152-LTTI***

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

Submit Procedure for Review and Approval (See ES&H Manual Chapter 3310 T1 OSP & TOSP Instructions – Section 4.2 Submit Draft Procedure for Initial Review):

- Convert this document to .pdf
- Open electronic cover sheet: https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-24048/3310T1Form.doc
- Complete the form
- Upload the pdf document and associated Task Hazard Analysis (also in .pdf format)

Distribution: Copies to Affected Area, Authors, Division Safety Officer
Expiration: Forward to ES&H Document Control

Form Revision Summary

Revision 1.7 – 02/25/2021 – Corrected link to Word doc; updated 'ESH&Q' to "ES&H'; other minor edits. No approval required.
Revision 1.6 – 06/23/2020 – Update section 15 to reflect guard number, what to do in an emergency, crew chief numbers, etc. approved by H. Fanning
Revision 1.5 – 04/11/18 – Training section moved from section 5 Authority and Responsibility to section 9 Training
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.
ES&H Division	Harry Fanning	04/11/18	02/25/24	1.6

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Jefferson Lab
Thomas Jefferson National Accelerator Facility

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1
Work Planning, Control, and Authorization Procedure)

Click For Word

Author:	C. Hernandez-Garcia	Date:	November 16, 2022	Task #: If applicable	

Complete all information. Use as many sheets as necessary

Task Title:	Gun Test Stand (GTS) operations	Task Location:	Bldg 18 (LERF), room 217 and room 109A
Division:	Accelerator	Department: Center for Injectors and Sources	Frequency of use:
Lead Worker:	C. Hernandez-Garcia		

Mitigation already in place:
Standard Protecting Measures
Work Control Documents

Ionizing Radiation Engineered Controls

- Concrete shielding at least 24" thick surrounds the GTS except in the vent to the LERF exit staircase.
- Concrete shield blocks are permanently installed outside roll-up door.
- Concrete shield sliding door (only access to GTS enclosure) is interlocked to the PSS so that opening it will drop the HVPS permit.
- Two baffle steel plates are permanently installed in the GTS vent hole to the LERF exit staircase. The baffles in the vent hole prevent access to the stairwell, which prevents personnel entry to the LERF vault.
- The high voltage power supply contactor is made up only when the PSS allows it.

Exposure to Laser non-ionizing Radiation
Drive Laser hazards are mitigated through use of Class 1 laser enclosures (hutch and laser beam line transport) and via redundant laser shutters interlocked to the Laser Personnel Safety System (LPSS). For laser alignment mode when a person needs to be in the enclosure with the laser turned on, administrative procedures require use of laser goggles, training and sliding steel entrance door interlocked to the LPSS. Laser hazards and procedures are fully covered under a separate document ***ACC-21-120940-LOSP.***

Oxygen Deficiency Hazard
The GTS enclosure is designed as an ODH 0 area. The ODH assessment for Nitrogen is addressed under a separate document JLAB-TN-07-082. The ODH assessment for SF6 is covered in the High Voltage Power Supply ***ACC-22-144152-LTTI.***

An interlock between the nitrogen source and the air-handling unit has been installed and is operational as an engineered control. The interlock is a fail-closed solenoid valve up-stream of the nitrogen manifold and mounted outside of the GTS enclosure that closes when the air handing unit is not working.

Oxygen Deficiency Hazard (continued)
There is one active ODH sensor installed under the HVPS tank. This ODH alarm will go off in the event of SF6 leakage. Two ODH sensor mounts have been installed in the north wall of the GTS enclosure, one close to the floor and one close to the ceiling for future use in case Liquid Helium is ever used.

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1
Work Planning, Control, and Authorization Procedure)

	Crushing during Sliding Concrete Shield Door operation, Engineered controls 1. Location of controls has been set to provide clear line of sight of the doorway. 2. Activation button must be kept depressed to move the door. 3.System pressure shall be set at minimum required to move the door

Sequence of Task Steps	Task Steps/Potential Hazards	Consequence Level	Probability Level	Risk Code (before mitigation)	Proposed Mitigation (Required for Risk Code >2)	Safety Procedures/ Practices/Controls/Training	Risk Code (after mitigation
1	Gun operation / Exposure to Ionizing Radiation	M	M	3	See Mitigations already in place	A Personnel Safety System (PSS) has been designed and implemented to protect individuals from ionizing radiation during high voltage and electron beam operations. The system has 3 Alarming Radiation Monitors (CARM) plus one more CARM linked to the LERF PSS system. A red flashing light will automatically be turned on in the GTS enclosure when the HVPS permit is allowed by the PSS. A sign just below the read flashing light is displayed indicating to exit immediately by pressing the concrete shield door crash button. The concrete shield door cannot be physically closed from the inside. Two-person sweep will be done prior to closing the GTS concrete shield door following procedures referenced in the GTS OSP. Magenta beacons are activated when high voltage interlocks are armed, indicating potential for ionizing radiation inside the GTS enclosure.	1

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Thomas Jefferson National Accelerator Facility

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1
Work Planning, Control, and Authorization Procedure)

Sequence of Task Steps	Task Steps/Potential Hazards	Consequence Level	Probability Level	Risk Code (before mitigation)	Proposed Mitigation (Required for Risk Code >2)	Safety Procedures/ Practices/Controls/Training	Risk Code (after mitigation
2	Laser operation / Exposure to non-ionizing laser radiation	M	M	3	See Mitigations already in place	Use of Class 1 laser enclosures (hutch) interlocked to the LPSS, use of laser goggles, training and LPSS laser shutters interlocked secured access during alignment	1
3	Magnet coil operation / Magnetic Field Hazard	M	M	3	A sliding concrete shield door Interlocked to the magnet power supply will prevent access to the magnet when it is energized.	A 5 Gauss boundary sign is posted at the GTS enclosure door and a 600 Gauss boundary is posted near the solenoid. Strong magnetic field will attract loose ferromagnetic objects, possibly injuring body parts or striking fragile components. Prior to energizing the magnet, a sweep of cordoned area will be performed for any loose magnetic objects. When personnel is required to work on the magnet while energized, that work will be conducted under a separate OSP, in which all personnel entering the 600 Gauss area will also be trained to remove ferromagnetic objects from themselves including wallet.	1
4	Enclosure occupancy / Oxygen Deficiency Hazard/SF_6 exposure	L	EL	1	See Mitigations already in place	In case of ventilation loss due to HVAC failure (noticed by the sudden absence of ambient noise and air flow in the enclosure) personnel must leave area immediately and proceed to muster point located in the LERF building main entrance.	1

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1 Work Planning, Control, and Authorization Procedure)

Sequence of Task Steps	Task Steps/Potential Hazards	Consequence Level	Probability Level	Risk Code (before mitigation)	Proposed Mitigation (Required for Risk Code >2)	Safety Procedures/ Practices/Controls/Training	Risk Code (after mitigation
5	Sliding Concrete Shield door operation/ Crushing	M	M	3	See Mitigations already in place	GTS OSP requiring operators be trained in the operation of the door and associated risks	1
6	Sliding Concrete Shield door operation/ Trip	L	M	2	A steel trench cover plate is already used	GTS OSP requires installing trench cover plate prior to entering and removal prior to closing.	1

Highest Risk Code before Mitigation:	3	**Highest Risk Code after Mitigation:**	1

When completed, if the analysis indicates that the Risk Code before mitigation for any steps is "medium" or higher (RC≥3), then a formal Work Control Document (WCD) is developed for the task. Attach this completed Task Hazard Analysis Worksheet. Have the package reviewed and approved prior to beginning work. (See ES&H Manual Chapter 3310 Operational Safety Procedure Program.)

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1
Work Planning, Control, and Authorization Procedure)

Form Revision Summary

Periodic Review – 08/13/15 – No changes per TPOC
Revision 0.1 – 06/19/12 - Triennial Review. Update to format.
Revision 0.0 – 10/05/09 – Written to document current laboratory operational procedure.

ISSUING AUTHORITY	TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	REVIEW DATE	REV.
ESH&Q Division	Harry Fanning	08/13/15	08/13/18	0.1

ODH Assessment

Date: **7 November 2007 Revised 24 June 2008**

Division: FEL

Location: **FEL Gun Test Stand (Rooms 109A, 109B, & 111)**

Assessment Author: **Mathew Wright & Dana Arenius**

Approval

Engineering Division Department Head: **Will Oren 12/14/07**

EHS&Q: _____

Facility Manager: _____

ODH Risk Assessment, FEL Room 109
March 20, 2007

Introduction

The following assessment addresses the risk of oxygen deficiency hazard (ODH) for the FEL (bldg. 18) room 109A. Because rooms 109B and 111 have openings to room 109A, they are also assessed by this document. The assessment is conducted according to the requirements of Appendix 6500-T3, "ODH Risk Assessment". Two general categories of ODH hazards are identified in the facility. These include sources of nitrogen and sulfur hexafluoride gas which can dilute the normal oxygen content with health effects as outlined in Appendix 6500-T3. It is recommended that a separate evaluation address sulfur hexafluoride as a toxic hazard in addition to what is covered here as an ODH hazard.

The following sections cover the modeling scope and methodology for cryogen and sulfur hexafluoride dispersion release, a description of the work space, risk assessment, failure rates of components, and requirements. The process work procedures presented in the May 1 2007 "GTS SF6 Gas Transfer System" review were considered in this assessment.

Model for Cryogen Dispersion Release (Ref Diagram Page 7 of 7)

The model for cryogen dispersion release of nitrogen is based on a ½ inch supply line at 80 PISG supply pressure with a ¼ inch solenoid valve. Because of the large capacity of the nitrogen dewar, the nitrogen source will be treated as an infinite supply source.

Because the nitrogen is considered to be an infinite source, the rooms have been modeled to limit the nitrogen flow and never let the oxygen levels go below the 18% by use of engineering controls. This means that there must be a limiting device in the nitrogen supply line located outside the room 109A. An interlock outside the room that will shut off the nitrogen source if fresh air supply is not on must also be provided.

The model for dispersion release of sulfur hexafluoride is based on a total source volume of 490 scf. One source of volume is a gas storage bag that is approximately 2500 gallons (335 scf) located outside. The other source of volume is the gun test stand vessel (HV tank) that is approximately 150 scf in room 109A. The HV vessel is pressurized to approximately 15 psig with the sulfur hexafluoride and therefore represents ~300 scf of gas. Because the sulfur hexafluoride is considered to be a dense gas with a specific density of 5, it is considered to be concentrated at the room floor level at ODH concentrations that yields a fatality factor of one (Fi). Room air is drawn from the FEL accelerator room through a stairway (room 111) via two wall air duct openings. The air duct opening into room 109A is six inches off the floor of room 109A. Therefore the oxygen level would be below 8.8% in room 109A and 109B less than or equal to this 6 inch height.

Six inches off the floor for rooms 109A and 109B would represent 573 cubic feet. If all the sulfur hexafluoride was to be released onto the floor, no sulfur hexafluoride would pour through the air duct. Sulfur hexafluoride gas flow would not be in the opposite direction of the air flow from room 111 into 109A.

One model for an oxygen deficiency hazard is based on the largest quantity of gaseous nitrogen available for use. A separate model is based on the total amount of sulfur hexafluoride that is possible. Failure rate estimates (P_i) are based on JLAB listed equipment rates under EH&S Section 6500. Fatality Factors (F_i) are derived from Figure 3, from EH&S Appendix 6500-T3. The sum of the failure product of the F_i and P_i determined the area classification in accordance with table 6 of Section 6500 of the EH&S manual.

Description of Work Space (Ref Diagram Page 7 of 7)

Room 109A has a floor area of 606.5 square feet with a 10 foot ceiling. At one end of the room is an intake duct to the air handling unit that supplies heated or cooled air mixed with fresh air to the FEL accelerator room. At the other end of the room is a hole in the wall that is open to the accelerator room and is covered with steel screen. Between the accelerator room and room 109A is a hallway (Room 111). Therefore, rooms 109A and 111 are considered air passage ways. There is one roll up door, normally closed, and a concrete door, normally open. The concrete doorway has a metal panel to eliminate air flow and any possible laser light that might come through the doorway. The doorway opens to room 109B.

Gaseous Nitrogen Sources

The gaseous nitrogen ODH source is a 20,000 gallon dewar. Liquid nitrogen is piped from the dewar to an ambient vaporizer. The gas that leaves the vaporizer is then piped to a header. The FEL has a connection to that header that supplies different locations at the FEL, including room 109A. This dewar represents approximately 1,900,000 standard cubic feet (SCF) of nitrogen gas at 300 Kelvin. If the nitrogen was accidentally released into an unventilated room, the oxygen level could become dangerously low if engineering controls were not in place.

Sulfur Hexafluoride Sources

The sulfur hexafluoride ODH source is from bottles kept outside. Those bottles are then vented into a large bag that is also outside. The sulfur hexafluoride is then drawn inside the room through piping and a pump to the gun test stand vessel. There are seven valves and approximately 20 elbows and fittings. The plumbing is mostly copper tubing with brazed joints. There are some flexible hoses.

Type of Ventilation

In accordance with Appendix 6500-T3, reliable ventilation may be considered a relevant factor for this ODH assessment on the nitrogen source only if the volume of air in the room is replaced with fresh air at a minimum of once an hour. There is no data at this time to support that the sulfur hexafluoride would be evenly mixed in the airspace if the ventilation is on.

ODH Risk Assessment

The following are a set of events for the nitrogen system associating the probability and fatality factors that are true only after the engineering ventilation control interlocks have been implemented in room 109A.

Event	**Spill Rate** SCFH	**Spill** scf	**%O2**	**Pi**	**Fi**
Fittings	310	1,900,000	>18	See note	0
Power Outage	0	0	21	See note	0
Operator Error	310	1,900,000	>18	See note	0
Valves	310	1,900,000	>18	See note	0
Hose	310	1,900,000	>18	See note	0

Pi Note: The probability factor Pi is assumed to be $0 \le Pi \le 1$ for this part of the ODH analysis. It does not depend on the value of Pi. For all values of probability, engineering ventilation interlock controls will maintain O2 levels >18% where the fatality factor Fi will always be equal to zero. **Therefore** $\phi = \sum P_i F_i = 0$ **for all values of Pi.**

The following are a set of events for the sulfur hexafluoride system associating the probability and fatality for rooms 109A & 109B.

Event	**Spill Rate** SCFH	**Spill** scf	**%O2**	**Pi**	**Fi**
Flanges, Closures, Elbows	See Note	300	<8.8	3.00E-07	1.20E-05
Pipes < 3", high quality	See Note	300	<8.8	1.00E-10	4.00E-09
Valves: orifices, flow, meters, (test)	See Note	300	<8.8	1.00E-08	7.00E-08
Welds	See Note	300	<8.8	3.00E-09	2.40E-07
FEL SF6 Vessel	See Note	300	<8.8	3.80E-06	3.80E-06
				S	1.61E-05

Spill Rate Note: This assessment does not account for the rate at which the sulfur hexafluoride would be released into the room. Instead, the total amount of sulfur hexafluoride was used.

The following are a set of events for the sulfur hexafluoride system associating the probability and fatality for room 111.

Event	**Spill Rate** SCFH	**Spill** scf	**%O2**	**Pi**	**Fi**
Flanges, Closures, Elbows	See Note	300	<8.8	See note	0
Pipes < 3", high quality	See Note	300	<8.8	See note	0
Valves: orifices, flow, meters, (test)	See Note	300	<8.8	See note	0
Welds	See Note	300	<8.8	See note	0
FEL SF6 Vessel	See Note	300	<8.8	See note	0

Pi Note: The probability factor Pi is assumed to be $0 \leq Pi \leq 1$ for this part of the ODH analysis. It does not depend on the value of Pi. For all values of probability, the O2 levels will remain >18% where the fatality factor Fi will always be equal to zero. **Therefore** $\phi = \sum P_i F_i = 0$ **for all values of Pi for room 111.**

Resultant Classifications

ODH Classification

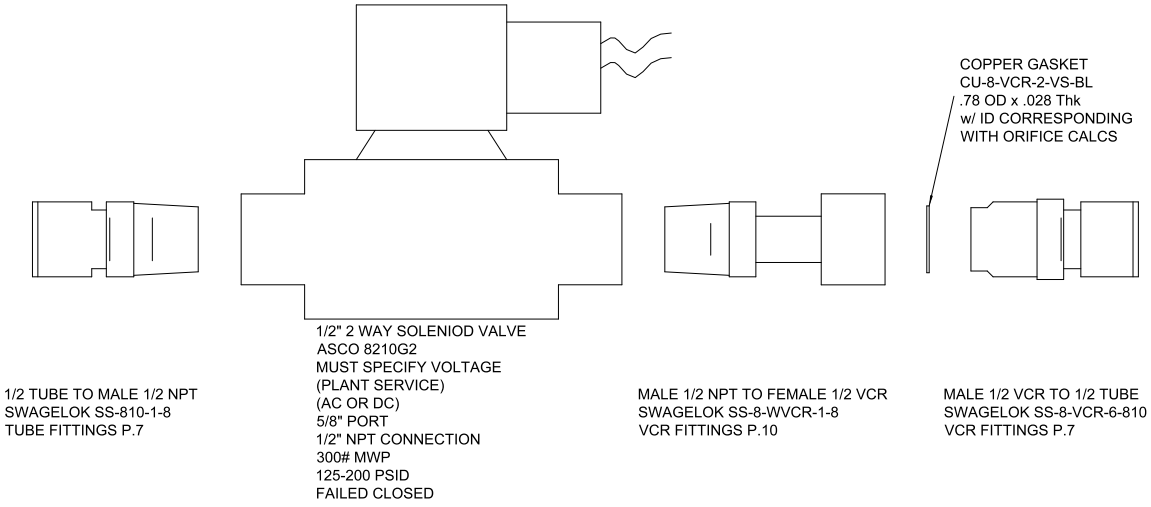
Because Φ is > 10^{-5} but < 10^{-3}, the **ODH classification is 2** for rooms 109A and B.

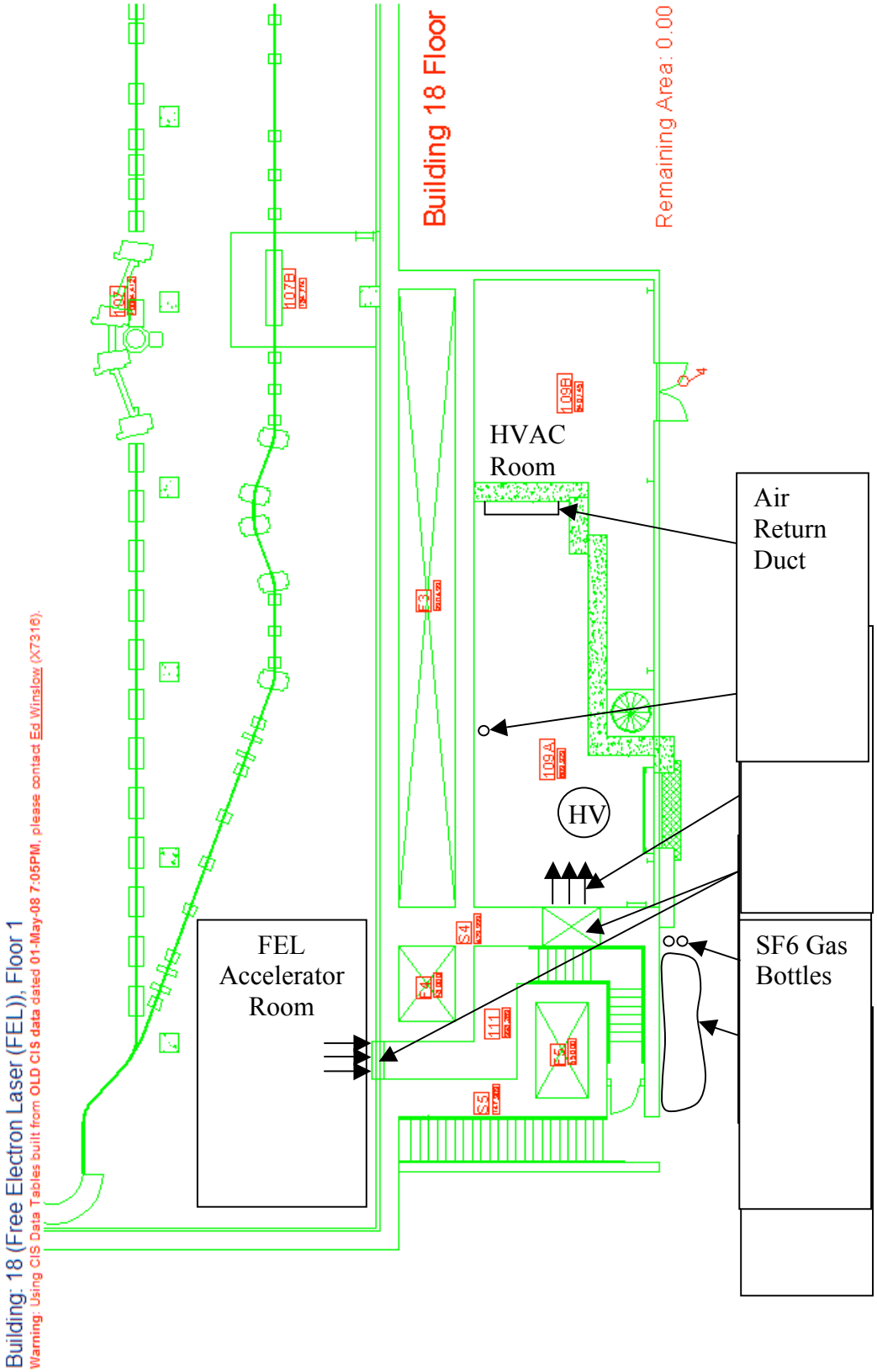
Because Φ < 10^{-7}, the **ODH classification is 0** for room 111.

Engineering Controls

The following engineering controls are necessary to provide a safe working environment while retaining an ODH 0 posting for the nitrogen source.

This analysis requires an interlock between the nitrogen source and the air handling unit. The interlock is to be a fail-closed solenoid valve up-stream and outside of the room that closes when the air handing unit is not working. Normally an orifice plate is installed, as shown in the diagram, but is not required for this analysis because there is already an orifice of 1/8 inch at the gas nitrogen header behind CHL. This will limit the N2 flow rates which allow the ventilation air to maintain O2 levels > 18%.




Building 18 Floor
Remaining Area: 0.00
HVAC
Room
Air
Return
Duct
HV
FEL
Accelerator
Room
SF6 Gas
Bottles
Building: 18 (Free Electron Laser (FEL)), Floor 1
Warning: Using CIS Data Tables built from OLD CIS data dated 01-May-08 7:05PM, please contact Ed Winslow (X7316).

By signing this page, you testify that you have read, understand, and agree to abide by the procedure specified in the above referenced work control document:

Serial Number: ACC-22-144906-OSP

Title: Gun Test stand (GTS)

Name	Signature	Date