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Jefferson Lab — Thomas Jefferson National Accelerator Facility

Operational Safety Procedure Review and Approval Form # 64784
(See ES&H Manual Chapter 3310 Appendix T1 Operational Safety Procedure (OSP) and Temporary OSP Procedure for Instructions)

Type:	***LOSP*** Click for OSP/TOSP Procedure Form Click for LOSP Procedure Form
Serial Number:	***ACC-17-64784-LOSP***
Issue Date:	***1/18/2017***
Expiration Date:	***1/18/2020***
Title:	***UITF Laser Systems***
Location: (where work is being performed) Building Floor Plans	***Test Lab - 1126B*** ***Test Lab - 1127*** Location Detail: (specifics about where in the selected location(s) the work is being performed): ***laser cleanroom and beam test cave***
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):	***Hansknecht, John (hansknec@jlab.org)*** Primary

Supplemental Technical Validations

Lasers Class 3B or 4 (Ultraviolet, Infrared, and Visible Light) (Bert Manzlak, Jennifer Williams)
Lock, Tag, Try (Paul Powers, Todd Kujawa)

Document History

Revision	Reason for revision or update	Serial number of superseded document

Comments for reviewers/approvers:	***Lock and tag is an appendix at the end of the LOSP. There is presently no laser, so LTT is not required, but it will be implemented when a laser delivery method to the beamline is established.***

Attachments

Procedure: ***UITF Laser Systems LOSP.pdf***
THA: ***UITF Laser Systems THA.pdf***
Additional Files:

Convert to PDF

Review Signatures	
Subject Matter Expert : Lock-> Tag-> Try	**Signed** on 1/13/2017 2:01:11 PM by Todd Kujawa (kujawa@jlab.org)

Approval Signatures	
Division Safety Officer : ACCCIS	**Signed** on 1/18/2017 3:44:14 PM by Harry Fanning (fanning@jlab.org)
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Safety Warden : Test Lab - 1127	**Signed** on 1/13/2017 2:11:05 PM by John Hansknecht (hansknec@jlab.org)
Subject Matter Expert : Lasers Class 3B or 4 (Ultraviolet-> Infrared-> and Visible Light)	**Signed** on 1/13/2017 3:43:16 PM by Bert Manzlak (manzlak@jlab.org)

Laser Operational Safety Procedure (LOSP) Form

(See ES&H Manual Chapter 6410 Appendix T1 Laser Operational Safety Procedure)

Issue Date:		**Expiration Date:**	3 years from official issue date
Title:	UITF Laser Systems		
Location:	Laser Cleanroom in bldg. 58 room 1126B and Test cave room 1127		
Description of Project	The project is a laser driven photo-electron gun for the UITF accelerator.		
Document Owner(s):	John Hansknecht	**Date:**	1/5/2017

Laser Inventory

Laser Serial # **	**Laser Class**	**Wavelength(s)**	**Maximum Power/Energy**
1. N/A Diode	3B and 4	405-455nm 630-680 760-860 1064 or 1560	1W 0.2W 0.2W 0.2W
2. PPLN SHG	4	780nm	3W
3. Nd:YVO4 & LBO SHG	4	532nm	11W
4. Near IR Fiber Laser	4	1064nm	5W
5. Mid IR Fiber Laser	4	1560nm	10W

****** Actual serial numbers tracked in annual report to LSO.

Approval Signatures:	**Print**	**Signature**	**Date:**
Laser System Supervisor:	John Hansknecht		
Laser Safety Officer:	Bert Manzlak		
Division Safety Officer	Harry Fanning		
Department or Group Head:	Matt Poelker		
Other Approval(s):			

Document History:

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

Distribution: ESH&Q Document Control (x7277, MS6B); affected area(s); Document Owner; Division Safety Officer

Introduction – In areas containing more than one laser, define operational sequence or parameters.

This document refers to laser class 1,3R,3B, and 4. These are hazard classes defined by ANSI Z136.1. The reader is expected to understand the meaning of these hazard classes.

This Laser Operational Safety Procedure (LOSP) addresses all aspects of safety and conduct specific to the operation and maintenance of the lasers used in the UITF Injector clean room and the UITF test cave. In the primary intended mode of operation, laser light is produced under a class 1 interlocked laser enclosure inside the clean room and then launched into a stainless steel armored fiber for delivery to a class 1 interlocked laser enclosure in the test cave, so there is no possibility of exposure to personnel.

During times where laser maintenance is necessary, the systems have engineered interlock controls that will allow either the test cave or the laser cleanroom act as a class 4 laser area. This will be described in detail under the "Laser Environment" and "Laser Interlocks" section below.

The primary light source for UITF operation is a 780nm laser delivered over fiber from a fiber laser amplifier. There may be a need to occasionally drive the electron gun with a different laser, which will also be connected to the engineered laser interlock system. This LOSP shall permit the temporary (less than 3 months) installation of any laser listed in the laser inventory if the need arises for a short term experiment. Such changes will be initiated with a TATL entry to provide notice and an opportunity for discussion with the LSO, affected laser workers, and Safety Systems Group (SSG) to ensure continuity of machine and personnel protection. Laser Experiments lasting longer than three months will require a revision or addendum added to this LOSP.

Personnel Only those authorized by the LSS are permitted to enter the location noted on the cover sheet of this document.	List: • Training and qualification requirements (including refresher training). • Medical requirements. • Spectator protection requirements.

A list of authorized laser personnel is maintained online within the Jlab Training Database for SAF161 training.

A Laser Worker must have completed SAF 161 "UITF Laser User Training". This means the Laser Worker has:

a) Been qualified by Jefferson Laboratory Occupational Health Physician (MED 02) as detailed in Section 6410 of the EH&S manual,
b) Taken a laser safety course (SAF 114O) administered by the laser safety officer
c) Read Section 6410 of the EH&S manual,
d) Read and understood this LOSP,
e) Received laser and laser room specific walkthrough training with the LSS and entered into the Jlab training database.

Accidental Eye Exposure: Accidental eye exposure to a laser beam requires ***immediate medical attention*** whether injury is apparent or not. If possible, the individual should remain and be transported in the upright position.

Spectator Protection Requirements: Injector Laser Workers may escort spectators in an interlocked laser area during alignment mode only after ensuring that the spectator is wearing appropriate safety eyewear and jewelry, watches removed. *Spectators must have received prior permission from the Laser System Supervisor before entering the interlocked laser area during alignment mode.*

Laser	Define: • Laser system specifications. • Define laser system components. • Copy of laser operating manuals or reference the location of the manual(s).

Lasers that can be installed and operated in the room are listed below:

Description: Diode lasers - Used as a direct optical source for an experiment on the laser table or used as to "seed" other lasers for wavelength or temporal control.

Type of Laser / Class	Semiconductor diode laser / Class 3A and 3B
Manufacturer	Ultimate manufacturers are unknown. Diodes are supplied by Thorlabs, Qphotonics, etc.
Model Numbers	Multiple model numbers. This information is not consequential for safety. All diodes are treated with equal concern based on power, wavelength, and beam shape.
Serial Numbers	Diode lasers are easily damaged and frequently replaced. Furthermore, vendors do not mark serial numbers on the diode housings because they are often too small. For this reason, serial numbers of seed lasers are not recorded in this LOSP.
Wavelength range	405nm, 445nm,630nm,700-900nm, 1064nm, 1560nm
Power Range	405nm to 0.5W, 445nm to 1W, all others up to 200mW.
Mode (i.e., time structure)	Worst case= pulsed at 250 MHz with 10ps Gaussian pulses. May also operate CW.
Beam Diameter (collimated, typical)	3mm
Divergence (uncollimated, typical)	0.35mrad +/- 10%

Description: Diode pumped 532nm laser

Type of Laser / Class	Frequency-doubled Nd:YVO4 / Class 4
Manufacturer	Jenoptik and Coherent
Model Numbers	Jenoptik (none) Coherent Verdi-V10
Serial Numbers	201,218,312, 248902, V10-A0436, V10-A0024
Wavelength range	532nm
Power Range	Up to 11 Watts
Mode (i.e., time structure)	CW
Beam Diameter (collimated, typical)	2.25mm
Divergence (uncollimated, typical)	0.35mrad +/- 10%

Description: Fiber Laser Amplifier at 1064nm

Type of Laser / Class	Fiber, single mode (class 4 at fiber output)
Manufacturer	IPG

Model Numbers	YAR-5K-1064-LP-SF
Serial Numbers	PA0605581
Wavelength range	1064nm
Power Range	Up to 5 Watts
Mode (i.e., time structure)	Worst case = 250MHz with 10ps Gaussian pulses
Beam Diameter (collimated, typical)	1.7mm
Divergence (uncollimated, typical)	0.35 mrad +/- 10%

Description: Fiber Laser Amplifier at 1560nm

Type of Laser / Class	Fiber, single mode (class 4 at fiber output)
Manufacturer	Keopsys & IPG
Model Numbers	Keopsys KPS-BT2-PEYFA-1560-PB-060-PM-FA. IPG EAR-5K-C-LP-SF. EAM-10K-C-LP
Serial Numbers	5090325, PA0605238, PA0605747, PA0706297, and future replacements
Wavelength range	1560nm
Power Range	Up to 10 Watts
Mode (i.e., time structure)	Worst case = 250MHz with 10ps Gaussian pulses
Beam Diameter (collimated, typical)	1.7mm
Divergence (uncollimated, typical)	0.35 mrad +/-10%

Description: Frequency doubling apparatus for creating 780nm from 1560nm *

Type of Laser / Class	Frequency doubling crystal. (Class 4)
Manufacturer	Jlab
Model Numbers	N/A
Serial Numbers	N/A
Wavelength range	1560nm input / 780nm output
Power Range	Up to 3 Watts delivered at 780nm
Mode (i.e., time structure)	Worst case = 250MHz with 10ps Gaussian pulses
Beam Diameter (collimated, typical)	2.5mm
Divergence (uncollimated, typical)	0.35 mrad +/- 10%

Description: Frequency doubling apparatus for creating 532nm from 1064nm *

Type of Laser / Class	Frequency doubling crystal. (Class 4)
Manufacturer	Jlab
Model Numbers	N/A
Serial Numbers	N/A
Wavelength range	1064nm input / 532nm output
Power Range	Up to 5 Watts delivered at 532nm
Mode (i.e., time structure)	Worst case = 250MHz with 10ps Gaussian pulses
Beam Diameter (collimated, typical)	1.5 mm

Divergence (uncollimated, typical)	0.35 mrad +/- 10%

* The frequency doubling apparatus is not a laser, but it modifies the wavelength delivered by the fiber lasers. This change in wavelength requires MPE calculations for eye and skin to cover both the fundamental and second harmonic wavelengths.

Hazards and Mitigation	Define: • Laser-specific hazards. • Occupational exposure hazards beyond laser light (e.g. fumes, noise, etc.). • Credible non-beam hazards (e.g. environmental hazards). • Describe all required personal protective equipment ES&H Manual Chapter 6410 Appendix T2 Laser Personal Protective Equipment (PPE) (include: clothing requirements (e.g.: no reflective jewelry, etc.).

Laser Specific Hazards

Hazard: The laser(s) described in this LOSP may produce optical energies that can cause temporary or permanent damage the eyes. The lasers may also produce a skin burn hazard.

Mitigation: This hazard is mitigated by training, professional conduct, optical beam-line layout, adherence to the *Use and Alignment procedures* listed in this document, and proper selection of laser protective eyewear by affected workers. The selection of laser protective eyewear is determined by the wavelength and power of the laser(s) in use as referenced in the *Required Calculations* section. Non-affected workers are protected by the system enclosure and room interlock system.

Hazard: Some of these lasers described in the LOSP are capable of producing laser generated air contaminants (LGAC).

Mitigation: We do not anticipate use of any materials within the beam enclosure that could produce these contaminants. If we find any LGAC production, laser operation will be shut down and the issue will be resolved by removing the offending material.

Non-Laser Hazards

Hazard: Historically we have listed high voltage as a hazard associated with lasers. Since the advent of solid state lasers, this is no longer an issue because they run at low voltage.

Mitigation: Any item requiring high voltage, (e.g. Pockels cells) will have electrically insulated connections making the high voltage inaccessible to the worker during operation.

Clothing Requirements: Laser workers and spectators must not wear jewelry or clothing that presents a specular reflection hazard.

Laser Environment System designs, including interlocks, require hazard evaluation review by SME.	Define: • Layout of the laser controlled area and/or table. (Show beam location in relation to user (waist height preferable).) • Interlock schematic (or similar) (including smoke detector interlocks). • Room lighting conditions during laser use and alignment procedure(s). • Targets. • Primary and all likely beam paths (open or enclosed).

The following paragraphs describe the normal production laser that will be found in the laser environment.

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VERY IMPORTANT CAUTIONARY NOTE: The lasers described within this LOSP are under remote EPICS computer control at all times unless specific steps are taken to gain manual control. Users should be

aware that any laser may start, stop, or change intensity without warning. These lasers are always treated as energized unless the system has been deenergized.
!!!

Class 3a Fiber Coupled Diode Lasers:

(a typical fiber coupled laser diode)

Description: The laser is a standard "C" band communications laser diode that is fiber coupled. Although the laser is rated at 20mW, the gain-switching technique at Jefferson Lab reduces the average output power to a maximum of 2mW. This laser acts as the "Seed" source for the Fiber laser amplifier.

The 1560nm wavelength produced by these lasers can damage the lens of the eye and cause cataracts upon overexposure. Viewing of energized un-terminated fibers is prohibited.

In normal operation, the fiber laser seed resides in the 1126B laser cleanroom and is launched into the fiber laser amplifier without free space travel, thereby forming a Class 1 Laser system. The fibers will remain terminated and the terminations are contained beneath the interlocked chassis. The chassis is labeled as containing Class 3a and 3b lasers in accordance with the ANZI Z136.1 -2000 standard. The bare fibers will not be accessible at any location to untrained / unauthorized personnel. Due to system losses, small in-line fiber laser pre-amplifiers are used to boost the seed power to about 4mW.

Class 4 Fiber Laser Amplifiers


(a typical fiber laser amplifier)

Description: The Fiber laser amplifier is a high powered fiber Erbium-Ytterbium gain medium which amplifies the light introduced to the input of the amplifier from a Class 3a "seed" laser.

The Fiber Laser amplifier is a commercial 19" rack mounted device which amplify incoming fiber sources. It is mounted below the Class 1 laser enclosure inside 1126B laser cleanroom. Both the incoming and exiting fibers fully contain the laser light and thereby form a Class 1 laser system. The amplifier face plate conforms to the CDRH requirements for emission warnings, keyed operation, anti-restart, etc. There are no user serviceable parts within the amplifier chassis. The output fiber from the chassis is permanently attached to the chassis, thus preventing the possibility of exposing personnel to the amplified light. The output fiber is taken into the interlocked class 1 enclosure on the laser table where it is terminated with a collimating optic. The light exiting this collimating optic is completely invisible and powerful enough to burn skin and eyes through direct illumination or specular reflection. It is immediately launched into the PPLN second harmonic crystal described below. The methods used to mitigate exposure to this light are described in detail with the Frequency Conversion Apparatus description.

Class 4 Frequency Conversion Apparatus

Description: A periodically polled Lithium Niobate (PPLN) crystal is used to frequency double the 1560nm output light from the fiber amplifier. This conversion of wavelength from 1560nm down to 780nm significantly impacts safety and eyewear requirements, so it is listed here as a laser source.

(A typical frequency conversion apparatus)

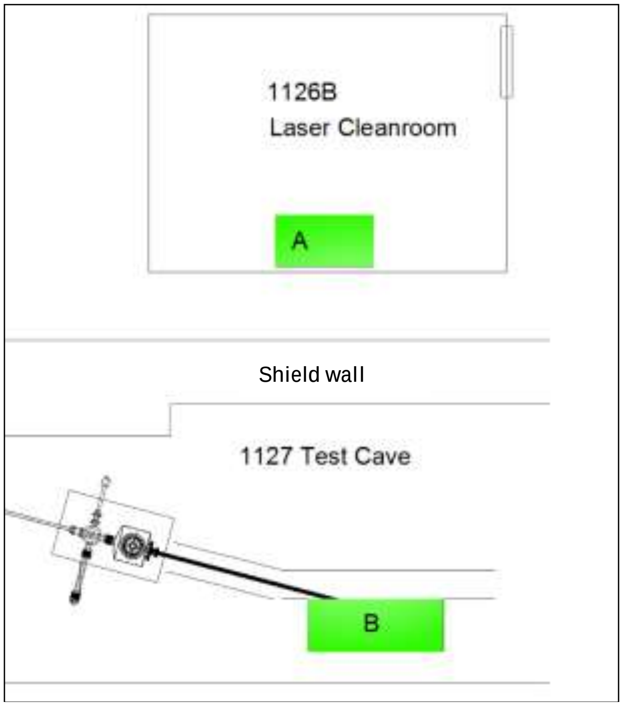
The photo above gives a clear overview of the apparatus. This apparatus is located inside the 1126B laser cleanroom class 1 interlocked laser enclosure. This apparatus is where the hazardous laser conditions are first encountered in the system. Until reaching this point, the high power light has been safely contained in an optical fiber, and is now launched into the periodically polled lithium niobate (PPLN) crystal which subsequently converts about ½ the incoming light from 1560nm down to 780nm. The residual 1560nm light is safely dumped. The useful 780nm light is reflected by a pair of mirrors out onto the main laser table. These mirrors are dichroic and serve to reflect only the 780nm light while allowing the 1560nm light to dump into a beam dump. The 780nm exiting light is both a skin hazard and an eye hazard affecting the cornea of the eye. It is worthwhile to note that there is also a very small (<2mW) amount of harmonic light produced at a wavelength near 530nm. This green light is produced by the PPLN crystal and is non-hazardous.
The entire apparatus is designed with close tolerances between the primary optics. This minimizes the possibility of inadvertently coming in physical contact with the 1560nm beam. This is important because of the highly invisible nature and high power of the 1560nm light.

***** Keep in mind that the high power 1560nm beam is not visible with the Find-IR-Scope that we are accustomed to use. The beam is only visible using a 1560nm rated IR viewer card. The fluorescent image produced on this card will be visible through the required protective eyewear *******

Laser eyewear for this apparatus must protect against exposure to the 1560nm and 780nm light. When performing active alignment of the PPLN crystal, it is appropriate to run the fiber amplifier at the lowest possible setting while still achieving second harmonic power. This further serves to reduce the chance of exposure to specular reflections from the 1560nm source.

Area Schematic:

Schematic 1 shown below is a pictorial representation of the laser areas. There is a class 1 interlocked laser enclosure (A) within room 1126B and a class 1 interlocked laser enclosure (B) in the 1127 test cave. A stainless steel armored optical fiber delivers light from point A to B.



Schematic 1; Plan view of laser cleanroom and test cave electron gun region.

Description of operation:
Case 1 Normal: Lids are in place on laser enclosures A & B. System is Class 1 laser safe.

Fault condition 1: If the lid is lifted on laser enclosure A, the laser trips off on interlock fault.
Fault condition 2: If the lid is lifted on laser enclosure B, a shutter on laser enclosure A closes to stop laser delivery into the optical fiber so there is no light that can reach enclosure B. There is a small control panel that shows the status of the interlock and shutter position at enclosure B so a worker can be confident in the operational status of the interlock.
Fault condition 3: If smoke is detected above enclosure A or B, the laser interlock trips the laser off.

Case 2 Laser work in 1126B: If laser work (alignment, etc) is occurring in room 1126B, the "room" interlock system for room 1126B is armed. Once armed, there are illuminated warnings outside the room and the door is controlled with a defeatable access control system. The door is magnetically locked and only authorized laser works are afforded access. Once the room interlock is armed, the lid of laser enclosure A can be lifted without tripping the laser. Note: Since 1126B is a class 4 laser area, there may be short term experiments on the other tables within this room that involve the lasers listed in inventory. In all cases, notification of wavelength and power and appropriate laser protective eyewear will be available in the gowning area of this cleanroom.

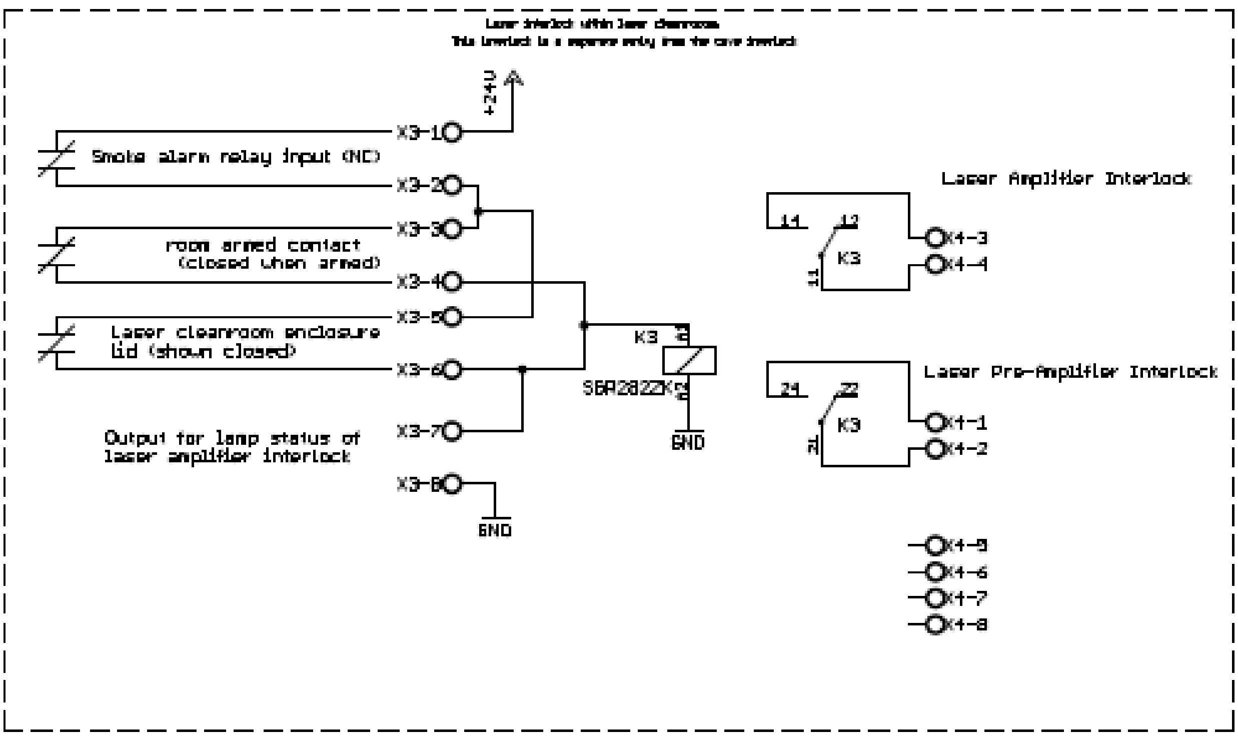
Case 3 Laser work in 1127 Test Cave: If work is required in laser enclosure B, there are two ways of performing the work described below:

Case 3A: We have the option of aligning the laser by connecting a class 3R laser to the fiber launch. The 3R laser is a 635nm laser less than 5mW in power and does not require laser protective eyewear. It would also allow other workers to be in the test cave area while the laser alignment is in progress.

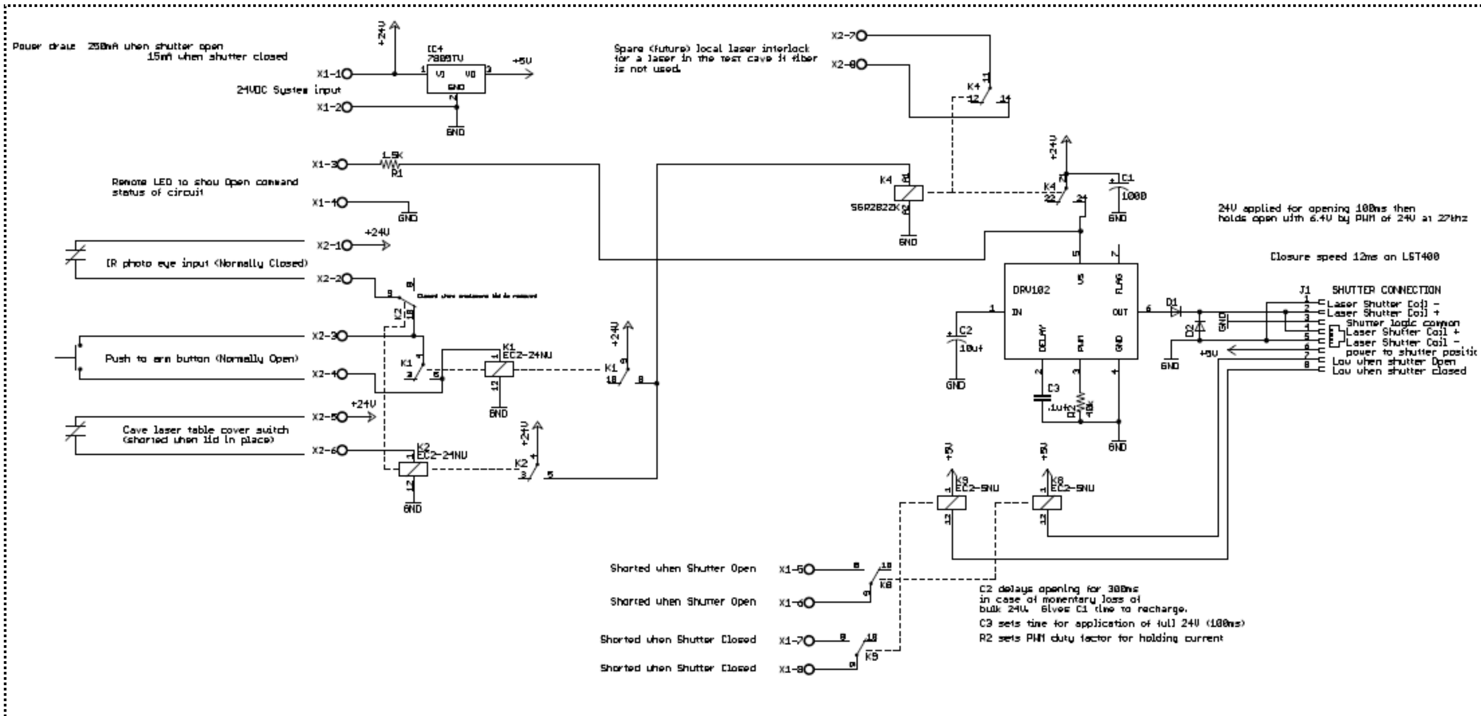
Case 3B: When the high power 780nm light requires alignment, the laser worker shall clear out all personnel from the test cave complex. A "Laser Alignment in progress" sign on a cone will be placed at both entry doors to the test cave complex. The worker can then return to the laser table and remove the lid on laser enclosure B. This will immediately trip the shutter in laser enclosure A. The worker can then wear the appropriate laser safety eyewear and push an "override" button inside enclosure B. This will cause the shutter to open and 780nm light will be delivered to the enclosure. During work, if a worker enters the cave in violation of the posted sign, the light curtains at the cave entryways will trip the shutter closed. Work can proceed only if the worker is escorted back out of the cave complex and the "override" button is pressed again. Upon completion of work, the lid is placed on enclosure B. The lid contacts automatically reset the circuit so it is in the normal condition and no longer in an override condition.

Case 3C: If a different laser from the inventory list were to be installed locally at laser enclosure B, the interlock system provides contacts to interlock this laser and perform the same safety function as described in case 3B above. At no time will we allow a condition where enclosure B is not a class 1 interlocked device.

Interlock system schematics:



Schematic 2: Enclosure A interlock.



Schematic 3: Enclosure B interlock

The schematics in this document are only intended to show the existence of the official design. Actual detailed schematics are located in the following directory: M:\inj_group\Official Electronic Design Packages\UITF laser interlock circuit.

Written Procedure for Use and Alignment	Provide: • All process steps – including unattended operation controls. • All process steps for detailed alignment – Include manufacturer's protocols for alignment. • Maintenance and service. • Off-normal and emergency procedures (e.g. beam loss, fire).

Procedural Considerations

1. Watches, rings, dangling badges, necklaces, reflective jewelry are taken off before any alignment activities begin. Non-reflective tools are used when beam is present.
2. Access to the room/area is limited to authorized personnel only.
3. Consider having someone present to help with the alignment.
4. All equipment and materials needed are present prior to beginning the alignment
5. All unnecessary equipment, tools, combustible material (if fire is a possibility) is removed to minimize the possibility of stray reflections and non-beam accidents.
6. Persons conducting the alignment have been authorized by the LSS

Alignment Methods to be used for this laser system:

1. Laser Protective Eyewear shall be worn at all times during alignment with laser rated > class 3R.
2. There shall be no intrabeam viewing with the eye.

3. Co-axial low power lasers should be used when practical for alignment of the primary beam.
4. Reduce the beam power through the use of ND filters, beam splitters and dumps, or reducing power at the power supply. Avoid the use of high-power during alignment.
5. Beam Control- the beam is enclosed as much as practical, the shutter is closed as much as practical during course adjustments, optics/optics mounts are secured to the table as much as practical, beam stops are secured to the table or optics mounts.
6. Areas where the beam leaves the horizontal plane shall be labeled.
7. Any stray or unused beams are terminated.
8. Invisible beams are viewed with IR/UV cards, business cards or card stock, craft paper, viewers, 3x5 cards, thermal fax paper, Polaroid film or similar technique. NOTE: The Find-R-Scope Infrared viewer is not sensitive to the 1560nm beam. Operators are aware that specular reflections off some of these devices are possible, and that they may smoke or burn.
9. Intrabeam viewing is to be avoided by using cameras or fluorescent devices.
10. Normal laser hazard controls shall be restored when the alignment is completed. This includes enclosures, covers, beam blocks/barriers have been replaced, and affected interlocks checked for proper operation.

Off-normal and Emergency Procedures

In Case of Fire, leave the area immediately and pull the nearest fire alarm. The fire alarm system will disable the laser power supplies.

Maintenance & Service

Routine maintenance of the laser systems consists of realignment and cleaning. These procedures are described in the vendor manuals and are typically considered "general knowledge" to laser workers trained on a specific system.

Vendor Service:
Alignment or replacement of parts by an outside vendor representative will require a JLAB escort qualified on this LOSP.

Maintenance requiring Lock-Tag-& Try:
The Electron beamline forms part of the Class 1 enclosure. If vacuum maintenance is being performed that will violate this enclosure, either the gun valve or the laser must be locked out using the Lock/Tag/Try procedure located in appendix A.

Laser Controls	• Describe all controls (administrative and engineering). (If a different control is recommended the rationale for not using a typical/recommended control.)

The engineered controls are essentially those schematic 1,2,3 and operationally described earlier.

The administrative controls are the contents of this LOSP, the labels affixed to the laser enclosure, and the signage posted on the entryways. These controls supplement the PPE requirements and engineered controls.

Required Calculations	• Maximum permissible exposure. • Optical density. • Nominal hazard zone.

The MPE, NOHD, and OD requirement for the eyewear are calculated using software package Easy Haz Industrial LSO (V2.12) by Laser Professionals Inc.

Laser parameters needed to calculate these values:

Assumptions:

- Beams always collimated.
- Beams are circular.
- CW beams: exposure 10 seconds for IR lasers, 0.25 seconds for visible lasers
- 7mm pupil diameter limiting aperture
- Collimated beam diameter is a "worst case" 1.5mm and lowest possible divergence of 0.2mrad.

Results are shown in the table below:

Laser Wavelength	Worst case pulsed conditions	Max average power at stated pulse conditions	Worst case Collimated Beam Diameter (mm)	MPE Ocular (W/cm^2)	MPE Skin (W/cm^2) CW	NOHD (meters)	Required OD (eyewear)
Laser diode 405-445 nm	250 MHz with 10ps Gaussian pulses	1W	1.5	2.55E-3	3.34	646	3.00
Any laser type @630-680 nm	250 MHz with 10ps Gaussian pulses	200mW	1.5	2.55E-3	3.11	707	2.31
Any laser type @700-900 nm	31 MHz with 10ps Gaussian pulses	5 Watt	1.5	2.55E-3	3.11	3530	3.71
Any laser type @532nm	250 MHz with 10ps Gaussian pulses	11 Watt	1.5	2.55E-3	3.11	5240	4.05
Any laser type @1064nm	250 MHz with 10ps Gaussian pulses	5 Watt	1.5	5.00E-3	1.00	2520	3.41
Any laser type @1560nm	250 MHz with 10ps Gaussian pulses	10Watt	1.5	1.00E-1	1.00E-1	798	3.02

Remarks:

1. OD rating printed on eyewear must exceed the calculated value of required OD.

2. Multiple wavelengths may be present in a given experiment. Eyewear must be selected that provides the proper OD for all wavelengths present.

Example: Our normal fiber laser system has 1560nm and 780nm beams present, thus eyewear selected must cover both wavelength bands with an OD meeting or exceeding the value determined in the chart above.

3. The specific laser from the laser inventory is not consequential for this table. The reasoning for this statement is:

a. All lasers in our inventory are run with collimated beams smaller than the 7mm pupil diameter.

b. One could argue that we are not going to get an accurate Nominal Hazard Distance (NOHD) result when we categorize all of our lasers to have a 1.5mm collimated beam diameter and 0.2mrad divergence. After all, our lasers each have a slightly different spatial profile. The typical NOHD for our lasers will range from 200 meters to several thousand meters. Since all lasers are run within a Class 4 laser room, the NOHD is known to be confined to the limits of the room. Any calculation error resulting from a slight variation of beam spatial profile is not consequential to our application.

c. All lasers run in Continuous Wave or at a high megahertz repetition rate that is "effectively" CW based on the calculations. The OD and MPE calculation results are thus driven by wavelength and average power alone. Skin MPE is undefined for our pulse structure, so CW is used to calculate.

4. For a given wavelength band, the lower wavelength of the band is the most restrictive. This value is used for the calculations to provide the greatest safety factor.

Labeling/Posting (See ES&H Manual Chapter 6410 Appendix T5 Laser Labeling/Posting Requirements	• Equipment/area labeling/posting requirements. • Area signs.

<u>Non- interlocked tooled housings:</u> must have indication on label that housing is not interlocked
<u>All beam pipes containing a laser beam must be labeled</u>: non-interlocked beam pipes must have indication on label that beam pipe is not interlocked
<u>Entrance to room must have ANSI laser sign</u> that includes entire class 3b and 4 laser inventory and indication of the nature of laser beams must be noted: invisible and visible
<u>Entrance to room must have a separate sign if class 3a lasers are in use in the room</u>
LSO will provide assistance for label and signage

Authorized/Trained Individuals	
Print Name/Signature	**Date**
Electronically listed in SAF161 List not maintained locally with this document.	

Appendix A – Lock, Tag & Try

Lockout/Tagout procedure for securing the UITF laser system for beamline vacuum work upstream of the laser entrance window.
Procedure produced in accordance with section EHS&Q manual section 6110 appendix T1

Scope of work: When a non-laser trained worker needs access to the beamline electronics inside the outrigger table or if disassembly of the vacuum system upstream of the laser table is planned, the laser system must be locked and tagged with an approved lockout device to prevent accidental exposure to the laser light to eyes or skin.

Step 1: Determine need for a written work control document.

Each tagger shall use this procedure when locking and tagging out the laser path for maintenance and repair. Each tagger must be either:
1. Laser safety trained and qualified on the UITF system or
2. Accompanied by a qualified laser system operator during the process.

Step 2: Determine hazards
The hazard is a class 4 laser beam capable of blinding or burning an individual who comes in direct contact with the beam. The hazard is completely mitigated by utilizing an engineered shutter mechanism to completely block the laser path.

Step 3: Notify others
Notify all affected employees. Tell them that you will be placing the equipment out of service until repairs or adjustments are completed. When two or more groups have separate or overlapping responsibilities for the equipment, the group requesting the work is responsible for notifying the other group or groups that the equipment will be placed out of service.

Step 4: Isolate energy sources
There are several places where an opaque clamshell device can be used to stop the transmission of light. These include:

a. Covering over the laser window
b. Disconnecting and covering the launch fiber that takes light from enclosure A to enclosure B.

If these are not suitable to the situation, the laser system supervisor will be able to point out the amplifier power source to be tagged. The amplifier has a removable power cord, so the cord receptacle safety lockout devices (stock # 6100-41050) must be utilized. Locks must be affixed so as to hold the devices in the safe (usually "off") position. Fill out tags completely and place them in such a way as to be immediately apparent to anyone who might attempt to operate the device. Tags must be attached by a durable means capable of withstanding a 50-pound pull, at least equivalent to a nylon cable tie. String and tape are prohibited.

Step 5: Remove potential energy
The lasers used in the injector have no stored or potential energy.

Step 6: Verify lockout
The tagger shall ensure that the LO/TO is effective.

Step 7: Perform the needed work. Check the integrity of the lock & tag when work lasts more than one shift.

Step 8: Prepare for re-energizing
When work is complete on the equipment or system, notify all affected people that the work is complete and ready for testing. Inspect to ensure equipment has been properly reassembled.

Step 9: Remove locks and tags
When all affected people are ready, each tagger removes their own locks and tags.

Step 10: Energize

1.0 Revision Summary

Periodic Review – 12/22/15 – No changes per TPOC
Revision 1.1 – 07/01/14 – TechPOC changed from D. Owen to B. Manzlak.
Revision 1.0 – 12/05/10 – Updated to reflect current laboratory operations.

ISSUING AUTHORITY	TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	REVIEW DATE	REV.	
ESH&Q Division	Bert Manzlak	12/22/15	12/22/20	1.1	

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Task Hazard Analysis (THA) Worksheet

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

Jefferson Lab — Thomas Jefferson National Accelerator Facility

Click For Word

Author:	John Hansknect	**Date:**	12/14/2016	**Task #:** If applicable	

Complete all information. Use as many sheets as necessary

Task Title:	Routine laser maintenance, installation, and operation			**Task Location:**	Bldg 58 room 1126B and UITF cave room 1127
Division:	Accelerator	**Department:**	Center for Injectors and Sources	**Frequency of use:**	Indeterminate
Lead Worker:	John Hansknect				
Mitigation already in place: Standard Protecting Measures Work Control Documents	None. This is the preamble to a new LOSP				

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)
	Laser exposure above MPE to eyes or skin	M	L	3	Follow processes outlined in the new LOSP	LOSP training and Job training	1
	Laser induced fire	M	L	3	Eliminate flammables from laser enclosure. Smoke alarm in 1126B or fire system in 1127 test cave shuts off laser.	The structure is engineered to prevent laser exposure to any flammable material.	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.)

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

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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-17-64784-LOSP

Title: UITF Laser Systems

Name	**Signature**	**Date**