San Francisco State University
Non-Ionizing Radiation Committee
Revision 3.4.1
Date: July 29, 2019

Laser Safety Program Manual

Prepared for: Non-Ionizing Radiation Committee
Prepared by: Linda Vadura, Laser Safety Officer
Date: Sep 16, 2025
Revision # 3.4.2

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1.0 Introduction

The term LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers are used in research and teaching laboratories and incorporated in commonly used devices such as CD players, supermarket scanners, classroom pointers and land survey instruments. Industrial uses include welding and cutting operations.

1.1 Policy Statement

Federal (OSHA)
29 CFR 1926.54
California (Cal/OSHA)
8 CCR 1801;
8 CCR 8416;
8 CCR 8888.

The campus policy on laser safety requires that all lasers and laser systems be operated in accordance with the **American National Standards Institute (ANSI) Z136.1-2014– Safe Use of Lasers**. This standard is referenced by Cal/OSHA as the basis for evaluating laser-related occupational issues. The Laser Safety Program is based on the ANSI standard and programs from other respected universities. **The (ANSI) Z136.5-2009 – Safe Use of Lasers in Educational Institutions** standard is also referenced as needed.

Program requirements include engineering and administrative controls, and training. All Class 3B and Class 4 laser operations must be reviewed by the Non-Ionizing Radiation Committee (NIRC) prior to new installations and at least every year thereafter.

1. A Laser Use Registration (LUR) application must be on file for every Class 3B and 4 laser at San Francisco State University.
2. All lasers subject to this program must be registered with the (NIRC) and issued a Laser Use Permit issued **before** they may be put into service.
3. Laser Use Permits expire June 30 and must be renewed each year.

1.2 Objective

The primary objective of the SFSU laser safety program is to minimize the potential for contact with skin and eyes and to control collateral hazards. All laboratories with lasers must establish standard operating procedures and setup their equipment in a way that meet this objective.

1.3 Scope

This Laser Safety Program applies to the use of Class 3B and Class 4 lasers and laser systems used in research and instructional laboratories at San Francisco State University (SFSU).

All faculty, staff and student researchers who work with and around these high-powered lasers are subject to the Laser Safety Program. While this program is specifically targeted to *employees*, the engineering controls and safe work practices established for a laser-containing laboratory also apply to the students and unpaid volunteers who operate them.

2.0 Laser Hazards

Most lasers are capable of causing an eye injury to anyone looking directly into the beam or specular reflections. Laser hazards are divided into two categories: beam and non-beam.

2.1 Beam Hazards – direct contact with beam

High power laser beams can burn exposed skin, ignite flammable materials, and activate toxic chemicals that release hazardous fumes, gases, debris, and radiation. Looking directly into a beam or its reflections from a specular surface can cause permanent eye damage.

2.2 Non-Beam hazards or indirect effects

Definition:

Maximum Permissible Exposure (MPE) is the level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. The criteria for MPE for eyes and skin are detailed in Section 8 of ANSI Z136.1-2007.

The equipment and optical apparatus required to produce the concentrated light and direct the beam may also introduce additional hazards associated with high voltage, high pressure, cryogenics, noise, radiation, and toxic gases. These collateral hazards include the risk of electric shock, fire from ignition of a combustible material, use of dyes and solvents, and vaporization of targets.

2.3 Evaluating Hazards

Before appropriate controls can be selected and implemented, laser radiation hazards, including associated lab hazards, for a particular operation must be identified and evaluated.

Eye	Acute exposure can cause retinal or corneal burns. Chronic exposure to high levels can cause cataracts or permanent retinal damage
Skin	Acute exposure can cause burns Chronic exposure to ultraviolet wavelengths (290-320 nm) can be carcinogenic
Chemical	Some lasers require hazardous or toxic substances to operate (chemical dye, Excimer lasers)
Electric Shock	Most lasers produce high voltages that can be lethal
Fire	The solvents used in dye lasers are flammable High voltage pulse or flash lamps may cause ignition Flammable materials may be ignited by direct beams or specular reflections from high power continuous wave (CW) infrared lasers

***SPECULAR** is a term often used around laser technology. It means "mirror-like".*

3.0 Laser Classification

The hazard classification scheme is based on the ability of the primary laser beam or reflected beam to cause biological damage to the eye or skin during its intended use.

Commercial lasers are classified by their manufacturer. The Laser Supervisor who operates or supervises the operation of a "modified" or "homemade" laser is responsible for classifying the laser per ANSI Z136.1-2007.

3.1 Hazard Class 1 and 1M

Class 1 lasers do not normally pose a hazard due to their low power output (≤0.4 μW) or through complete enclosure of the beam. Because Class 1 systems are incapable of causing eye damage (unless viewed with collective optics for 1M) they are therefore exempt from any control measures. Examples include CD players and supermarket scanners.

Class 1M *could be a hazard if collective optics are used.*

3.2 Hazard Class 2 and 2M

Class 2M*, same as Class 2, but with a highly diverging beam that could cause damage if collective optics are used.*

Low powered lasers with a power output under **1 mW** and with wavelength of **4 -7 μm** (visible light) that don't cause eye damage unless viewed directly for an extended period of time (i.e., 15 minutes). Examples include some laser pointers and scanners. See *Appendix A* for a Laser Pointer Advisory.

3.3 Hazard Class 3R and 3B

Medium powered lasers capable of causing eye damage with short exposure to the direct or specular reflected beam. Below are brief classification criteria. See ANSI Z136.1 (3.3) for full details.

Class 3R – lasers with a power range of **1–5 mW** that don't normally pose a hazard when viewed directly with an unprotected eye, but may present a hazard if viewed with collecting optics. Some laser pointers fall into this range.

Class 3B – lasers with a power range of **5-500 mW** ***continuous*** (< than **125 mJ** ***pulsed***), that can present eye and skin hazards if viewed directly or via specular reflections. 3B lasers do not produce hazardous diffuse reflections, unless viewed with collecting optics. No fire hazard presented.

AEL *The maximum accessible emission level permitted within a particular laser hazard class*

3.4 Hazard Class 4

Class 4 lasers and laser systems are those that emit radiation that exceed the Class 3B **AEL**. High power lasers (greater than **500 mW** ***continuous***) are capable of causing injury to the eye and skin, as well as producing dangerous specular and diffuse reflections. Class 4 lasers and laser systems can cause severe skin damage and can ignite flammable or combustible materials, such as cardboard, paper files, etc..

4.0 Inventory & Registration

The Non-Ionizing Radiation Committee (NIRC) requires the registration of all Class 3B and Class 4 lasers and laser systems because they are covered under this Laser Safety Program.

4.1 Inventory of Class 3B and Class 4 Lasers

The Laser Safety Officer (LSO) maintains an inventory of all existing Class 3B and Class 4 lasers and laser systems and, along with the Non-Ionizing Radiation Committee, evaluates new acquisitions.

All new Class 3B and Class 4 lasers or laser systems must be *registered* with the Non-Ionizing Radiation Committee prior to installation. This procedure is to assure that all laboratories using high-powered lasers are evaluated for safety controls before the laser is put into service.

4.2 Laser Use Registration Form

The Principal Investigator (PI), referred to as the "Laser Supervisor", must initiate the registration and approval process by submitting a copy of the purchase request and the completed **L**aser **U**se **R**egistration (LUR) form in ***Appendix B*** to the Non-Ionizing Radiation Committee for their review. When the review process is complete, they a copy of the approved LUR will be returned to the Laser Supervisor.

Acronym:

NIRC: Non-Ionizing Radiation Committee

Modification or termination of an LUR is usually done at the request of the Laser Supervisor. Under special circumstances, the NIRC may modify or terminate the LUR if the health and safety of users and others could be compromised. The LSO maintains LUR's and reviews them as needed.

Everyone has a basic duty to maintain a safe and orderly workplace and to behave in a safe and responsible manner. In addition to this basic duty, employers and their employees have specific responsibilities in implementing this program.

4.3 Laser Use Permit

Each Class 3B and Class 4 laser with an approved LUR, will be issued a "Laser Use Permit" that is valid for one year. Each Laser Supervisor will have to submit a new LUR to the NIRC for review. This review will include

- an inspection conducted by the Laser Supervisor and at least one NIRC member
- verification that all personnel with access to the laser are "authorized"
- verification that refresher training was completed

1. The Laser Use Permit must be posted in the laser room.
2. All Laser Use Permits automatically expire on June 1 of each year.

5.0 Program Organization

5.1 Department Chairs

Department Chairs are responsible for ensuring that both new and existing faculty and staff are aware laser administrative protocols and that they adhere to them. This is achieved by the following actions:

1. Encourage laser-using PI's and Staff Managers to operate their lasers safely in accordance with the established Laser Safety Program and to speedily correct deficiencies as they occur.

2. Assist the Laser Safety Officer in implementing improved safety techniques, procedures, and equipment when questions arise with faculty and staff.

5.2 Laser Supervisors

Laser Supervisors (Principal Investigators (PI's) or Staff Managers) are directly responsible for maintaining a safe lab and for implementing the Laser Safety Program as follows:

1. Complete the Laser Use Registration form for each Class 3B and Class 4 laser and submit it to the Laser Safety Officer (LSO);

2. Establish and post or otherwise make available standard operating procedures in the lab;

3. Contact LSO to enroll new users in a laser safety orientation and ensure prospective Laser Operators complete training requirements See ***Appendix C;***

4. Instruct Laser Operators in equipment-specific safety in operating the equipment;

5. Enforce safety recommendations including the correct and consistent use of guards, interlocks, and personal protective equipment (PPE);

6. Ensure that all Laser Operators operating under the LUR have completed equipment-specific training (OTJ) before allowing unsupervised use;

7. Identify and manage control measures for beam and non-beam hazards;

8. Inform the LSO of any modifications or location changes which could affect laser classification or increase safety risks;

9. Investigate and report accidents and near misses to the LSO or EH&S as soon as possible. See ***Appendix D*** for reporting form.

5.0 Program Organization (continued)

5.3 Laser Operators

Laser Operators must be enrolled as "Authorized Laser Operators" in order to operate or use the Class 3B or Class 4 laser(s) unsupervised.

To be eligible for authorized laser operator status, each applicant must be in one of the following categories

1. Paid Employee
2. Enrolled Student
3. Official Volunteer Employee (*Approved by HR)**

***Laser Supervisors:**
Contact the Department Office for assistance with registering volunteers, un-enrolled students or visitors as Volunteer Employees.

To obtain - and maintain - "Authorized Laser Operator" status requires the following actions:

1. Attend laser safety orientation and job-specific training sessions;
2. Follow laboratory administrative, alignment and standard operating procedures when operating high-powered lasers;
3. Use interlocks, shields and other protective devices as designed and not attempt to bypass or disable them;
4. Notify the Laser Supervisor of an exposure incident, near miss, suspected hazard or departure from established operating procedures;
5. Wear or use required protective equipment consistently and correctly;
6. Use only those Class 3B and 4 lasers they are specifically authorized to use by the Laser Supervisor;
7. Make sure that visitors/observers are protected from laser hazards.

5.0 Program Organization (continued)

5.4 Laser Safety Officer

The Laser Safety Officer (LSO) is responsible for monitoring the laser safety program and keeping it up-to-date. The LSO is the primary laser capacities:

1. Liaison between the Laser Supervisors, Laser Operators, EH&S and NIRC;
2. Laser safety resource, providing recommendations and information;
3. Initial laser area evaluator for LUR submissions;

4. Document control person for records and materials associated with Class 3B and Class 4 lasers;
5. Trainer in general laser safety;
6. Participant in accident investigations;
7. Recommends protective equipment i.e., eye wear, barriers, screens, etc., as may be required to assure personal safety;
8. Audits the proper operation and effectiveness of protective equipment, laser facilities, and lasers at least annually.

5.5 Non-Ionizing Radiation Committee

The Non-Ionizing Radiation Committee (NIRC) has jurisdiction over all aspects of the laser safety program, including enforcement of the program. The NIRC has the authority to suspend any operation that constitutes a health or safety hazard to the laser operators, building occupants, or the general public. The NIRC is responsible for monitoring controls of laser hazards and for general program oversight.

- Verifies classification of lasers and laser systems;
- Evaluates hazards in the laser set-up;
- Assures that prescribed control measures, as defined by the LUR, are in effect;
- Approves and modifies operating protocols as safety, regulatory, or operational needs change;
- Approves installation of Class 3B or Class 4 lasers and laser facilities or modification of existing equipment, prior to use;
- Reviews Laser Safety Officer's reports

Members include the LSO, administrator/MPP, and at least one faculty member from laser-using departments. The NIRC Chair is one of the faculty members on the committee. The NIRC meets at least once per year and as needed.

6.0 Inspections

6.1 Inspections

Prior to operation, all new Class 3B and 4 lasers and facilities shall be inspected by the LSO or another member of the NIRC. PI's should periodically perform their own inspections and promptly report problems or changes affecting safety. A laser operator with a safety concern may request an evaluation by the LSO.

Laser lab inspections will be conducted at least once annually by one or more NIRC members. If deemed necessary by the NIRC, a qualified outside vendor may be hired to inspect Class 3B or 4 lasers to ensure proper operation.

7.0 Medical Monitoring

7.1 Eye Exam Policy

People who work with high-powered lasers are at risk of burns to the skin, cornea, and retina as well as temporary blindness. Exposures to a direct or reflected beam can cause permanent damage to skin or eyes, although risks to workers are primarily from accidental acute injuries.

The Laser Safety Program does not require pre-placement eye exams.

Following a laser-related injury or suspected exposure to the eye, a post-incident medical evaluation may be required.

A closing, post-employment, eye examination may be recommended in certain cases when the job assignment is completed.

8.0 Incident or Accident Procedure

8.1 Handling a Laser Incident

Following an exposure to the eye, contact the Laser Supervisor or LSO as soon as possible. If after hours, contact University Police.

Evenings and on weekends, contact University Police for assistance.

- From campus phones: 911, 9-911, 8-2222
- From cell phones: 415-338-2222

During standard working hours, someone must accompany the person to the Student Health Services building for evaluation and incident reporting.

Never intentionally stare into a laser beam or direct it into one's eye

Medical examinations following an injury from laser beam exposure may be referred to an offsite occupational clinic.

9.0 Training

All staff, faculty and students operating Class 3B and 4 lasers are required to attend a laser safety awareness course presented by the LSO or other NIRC member. Following this initial training, the Laser Supervisor or designee will provide and document (job) machine-specific training.

Exemptions from the *general* laser safety training may be granted by the NIRC after reviewing previous training and experience.

9.1 Authorized Laser Operators/Users

Laser Operators have these documents on file:

1. Filed Registration

2. General Laser Safety Orientation

3. On-The-Job (Laser-Specific) Operations training (OTJ)

Only qualified and authorized personnel are allowed to operate Class 3B and Class 4 lasers. Laser Supervisors shall maintain a list of authorized laser operators and make sure they get the required training.

A. How to authorize laser operators

1. Fill out a form to request enrollment in the laser safety program
   - Submit an "Laser Operator Registration Request" to the LSO
   - To be "authorized, all personnel must have an SFSU ID and be an enrolled student, paid employee, or volunteer employee.

   Note: Visitors, Post-Docs, un-enrolled students must be registered as *"(Official)* Volunteer Employees" with Human Resources

   Contact department office staff for assistance with this process

2. Schedule a *General Laser Safety Orientation* session with the LSO
   - OTJ training must be completed within **90 days** of session
   - The Laser Supervisor must sign the OTJ form, but his/her designee may perform the job-specific training with the laser.

3. Review lab-specific rules and safe laser work practices
   - Use the OTJ form to document the lab/equipment-specific training
   - Submit the completed and signed form to the LSO

See ***Appendix C*** for the Laser Operator registration and training forms.

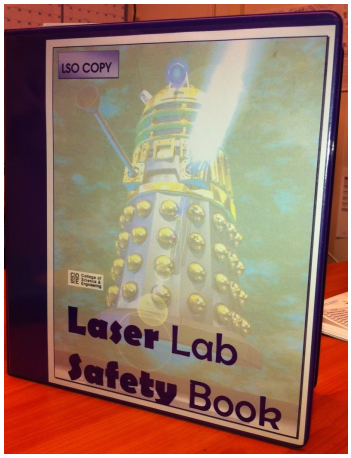
B. Partial list of information to review in OTJ training:

- Review the Laser Safety Manual;
- Review the operating and safety instructions furnished by the manufacturer;
- Learn alignment and standard operating procedures;
- Know security rules and special precautions to safely conduct research;
- Understand and use interlocks and beam control measures;
- Know emergency, start-up and shutdown procedures;
- Perform hands-on demonstration and skills testing.

9.2 Refresher Training

Laser Operators, including Laser Supervisors, are required to attend an annual refresher training session to maintain Authorized User status.

10. General Laser Work Practices



10.1 Laser Lab Safety Binder

Each Class 3B and 4 laser lab is issued a 3-ring safety binder that includes at least the following documents:

- **Provided by LSO**
  - Laser Safety Program Manual
  - Copy of the Laser Use Registration (LUR)
  - Evaluation of Laser Hazards
- **Supplied by Laser Supervisor**
  - Lab -specific Safe/Standard Operating Procedures (SOPs)
  - Completed OTJ Training form for each currently authorized laser operator
  - Completed Laser Operator registration forms signifying that all are paid employees, currently enrolled students, or "Acknowledged Volunteer Employees"*

* on file with campus HR for each non-enrolled student, unpaid staff, visitor and volunteer.

10.2 Laser Pointers

Do not point a laser beam at anyone.

Check warning label on laser pointer

Laser pointers rated at less than 5mW, may be used in classrooms, seminars, and research labs without registering them first with the Laser Safety Officer and the Non-Ionizing Radiation Committee (NIRC).

These Class 2 and Class 3A/R laser pointers have a low risk of causing serious or long-term injury when used properly. See the laser pointer safety advisory in ***Appendix A*** for more details.

1. Laser pointers that meet FDA (Federal Department of Agriculture) standards will be labeled with hazard classification, power output and a warning.
2. Class 3B and Class 4 laser pointers may not be used at SFSU without prior approval and registration.
3. Guest speakers and part-time lecturers who use laser pointers need to comply with the advisory in Appendix A.

10.3 Laser Eyewear

Eye protection suitable to the laser class and wavelength must be provided and worn within the laser control area during operation and alignment if there is a potential for exceeding the MPE limit. Exceptions may be approved in the written SOPs or by the LSO if the eyewear produces a greater hazard than when eye protection is not worn, such as in low-light situations.

Because various wavelengths of laser radiation require different eyewear, more than one type of laser should not be run simultaneously in the same laboratory unless they are under the control of the same person. The laboratory must be equipped with eye protection that is suitable for the laser(s) in use.

A. Laser eyewear must meet the following criteria

- Be able to withstand the maximum power of laser radiation likely to be encountered
- Be able to absorb the specific wavelength of radiation that is being used
- Be clearly labeled with its designed wavelength, the optical density (OD) at that wavelength and the maximum power rating
- Be inspected by the laser operator to ensure that pitting, cracking and other damage will not endanger the wearer
- The quantity of eyewear on hand must be sufficient for the expected number of daily users

No single type of eyewear will provide protection against all wavelengths of laser radiation. Lasers that can be tuned through a range of wavelengths present special problems. Broadband laser goggles must be chosen with great care. If there is any doubt regarding the suitability of a particular type of eye protection, contact the LSO for guidance

10.4 Safe Laser Lab Set-up

The following list of safe practices describes basic and currently accepted ways to minimize injury and property damage.

1. Isolate the laser from areas where untrained or unauthorized persons may be attracted by its operation.
2. Lock and secure doors when the laser set-up is unattended to keep out unauthorized staff, students, and visitors.
3. Enclose the laser beam to the extent practical.
4. Post "DANGER" signs at room entrances that include classification, operating wavelengths, and maximum power output.
5. Set up laser so that the beam path is either above or below normal eye level (roughly below 4.5 ft or above 6.5 ft)

10. General Laser Work Practices *(continued)*

6. Minimize the potential for specular reflections with shielding and by removing unnecessary reflective surfaces.
7. Provide adequate and fire-resistant covers for windows to hallways or other outside areas.
8. Terminate or "dump" the main and reflected beams with an inert, non-combustible material.
9. Ensure that electrical installations meet electrical safety standards.
10. Set up computer workstations, etc. so they are either shielded or out of the way of the beam or laser setup.

10.5 Laser Use Safety Practices

Following basic safe work practices minimizes the risk of injury and accidents.

1. Use the minimum power level required for the application.
2. Never look directly into the laser beam or at a specular reflection
3. Clear all personnel from the anticipated path of the beam
4. Allow only personnel directly involved with the current laser project to work or stay in the laser hazard zone—especially during alignments and when beam is exposed.
5. Orient the beam so it is not directed toward doors or aisles and clearly identify the beam path
6. Remove jewelry, reflective objects, and mirrored surfaces to minimize specular reflections
7. Securely mount the laser system on a stable platform and confine primary beams and reflections to the optical table
8. Use alignment eyewear, not the naked eye, to aim or align the beam.
9. Do not remove parts of the housing, service access panels or disable any safety interlocks qualified technicians. Qualified technicians should perform all repairs.
10. Provide an audible or visual indicator that shows when power to the laser is on as a warning system. An interlocked barrier is recommended as an engineering control
11. Check protective eyewear for damage and wavelength and OD information on the frame before using.
12. Be familiar with the lab's written safe work practices and policies.

Warning signs alone are not considered sufficient to control access

11. Requirements for Class 3B and Class 4 Lasers

The following requirements are taken from ANSI Z136.1-2007 and apply to the use of Class 3B or Class 4 lasers. This standard also serves as a reference for additional guidance on engineering controls available to minimize hazards.

11.1 Door Sign

A Danger sign per (ANSI136.1-2007) must be posted on each entrance to a laboratory with a Class3B or Class 4 laser. The wavelength and type of laser must be stated on the sign.

11.2 Standard Operating Procedures

Laser operators must be familiar with the procedures and practices necessary to work safely with the equipment. Hazard assessments can be helpful in preparing written operating procedures.

All Laser Supervisors are required to write standard operating procedures (SOP) for work with Class 3B and Class 4 lasers detailing alignment, operation, start-up, shut down and maintenance procedures.

SOP's should be posted near equipment or on lab doors or easily available on file in the lab

For assistance with writing SOPs, contact the Laser Safety Officer.

11.3 Safety Interlocks

NEVER disable or override an interlock or guard during normal operation

In order for interlocks to be effective in preventing laser contact or electric shock, they must be strategically placed and they must be used consistently. The PI should test interlocks periodically make sure they are working properly.

- Equip access doors to a controlled area with a safety interlock to prevent laser operation when the interlock circuit is broken
- Interlocks must be designed so that they cannot be re-energized without manually resetting the system

Alternate protection: The PI may substitute a procedure or engineering control, such as an alarm system, that provides the same level of protection as the interlock. The PI must request this *variance* in writing and the NIRC must approve it before using the alternate method.

11.4 Laser-control Areas

A designated laser-control area must meet these guidelines:

- Limited access with covered windows and doors
- Only diffuse or non-reflecting materials inside
- Fully enclosed room or area
- Access during laser operation requires authorization
- Circuit breakers must be identified for each laser
- Laser Operators may not wear

11.5 Beam Control

The beam path, including the target area should be surrounded by an enclosure including interlocks that prevent operation unless enclosure is secure;

Alternate Protection: If total enclosure is not practical, both the beam and any strong reflections must be terminated at the end of their useful path using such devices as backstops, shields or beam traps;

- Enclose or shield specular reflecting surfaces if diffusely reflecting materials can't be used;
- Class 4 lasers must have beam stops made of fire-resistant material;
- Direct or reflected beams that could exceed the MPE must be mapped and shielded to limit excessive radiation;

If it is necessary to view a beam, directly or with optical viewers, special provisions, such as filters or attenuators, must be provided and an SOP for this operation prepared.

11.6 Invisible Lasers

Lasers that emit invisible beams (ultraviolet or infrared) must be equipped with audible or visible warning devices that are detectable from all areas of potential exposure

- use appropriate laser eye wear at all times
- ensure eye wear allows user to see warning devices
- Control UV radiation to levels below the MPE for the wavelength being used
- shield beams to avoid hazardous by-products i.e., ozone
- wear long-sleeved coats, gloves and face protection
- Infrared beam enclosures and backstops must be made of IR-absorbing material

11. Requirements for Class 3B & Class 4 Lasers *(continued)*

11.7 Maintenance or Adjustment

Sometimes it is necessary to remove protective enclosures or override interlocks or other safety devices for service adjustments, repairs, or maintenance. In this situation, only a qualified service representative or knowledgeable PI may perform the work. Prepare the area as follows:

- Restrict access;
- Specify eye protection designed for the laser wavelength and any other required protective clothing;
- Ensure all optical paths from the restricted-access area are adequately covered to prevent escape of laser radiation and prevent exposure at or above the MPE.

COLLATERAL RADIATION
refers to radiation other than that associated with the laser beam itself such as ultraviolet, infrared ,and microwave.

11.8 Controlling Collateral Hazards

Chemical and physical hazards in the laser area, other than radiation, also need to be controlled to minimize the risk of injury just as they should be in lab operations that don't use lasers.

The more prevalent collateral hazards are listed below:

- Electrical Systems – follow all codes and safe work practices.
- High voltage – avoid live circuits and combustible materials
- Power outage – provide emergency lighting
- Hazardous materials – prevent contact with beam
- Dye lasers—avoid exposure as they are composed of a complex fluorescent organic dye dissolved in an organic solvent that is usually toxic and flammable
- Chemicals – follow established chemical handling procedures

12. Class 1 Enclosed Laser System

12.1 Changing Classification to a Class 1 Laser

A PI may request a reclassification of the laser system. Some laser systems can be downgraded to a Class 1 system if the laser can be completely contained. The performance standards below must be met and described in writing before the NIRC can review and approve such a request:

- Protective housing must prevent escape of laser radiation and access by personnel when laser is in operation
- Personnel performing maintenance or adjustments must comply with the control measures for the higher laser class
- Install safety interlocks wherever the protective enclosure can be opened or removed.
- Install fail-safes so that if a failure occurs in one protective measure the laser still meets the requirements for complete enclosure.

12.2 Servicing a Class 1 Laser

Class 1 laser equipment, such as 3-D printers, welders, and cutters, used in workshops, engineering labs, and construction facilities are usually exempt from the laser safety program requirements. However, if maintenance, repairs, or laser re-alignment requires the enclosure to be removed while in operation thus exposing the laser beam, the laser safety program will apply to these operations.

Contractors servicing laser equipment with Class 3B or Class 4 lasers inside, must erect barriers around the work areas in accordance with accepted practices and this program.

SFSU staff, faculty, and other personnel authorized to service such equipment, must complete the training and laser use authorization requirements, and comply with all the provisions of the laser safety program,

12. Laser Safety for Theater Arts

Some laser lights have the potential to cause eye damage to audiences, so theater and creative arts operations that use Class 3B and Class 4 lasers are subject to the Campus Laser Safety Program.

Use of laser lights in outdoor theaters can present a threat to aircraft operators. Therefore, the use of laser lights in outdoor productions is prohibited unless prior permission is obtained in writing from the Federal Aviation Administration (FAA). Requirements for outdoor use are taken from ANSI Z136.6–2015, "American National Standard for Safe Use of Lasers Outdoors".

12.1 Basic Requirements

Many lasers that are used in entertainment, theater and public exhibition work emit beams that are bright enough to cause a significant eye injury risk. High power lasers with radiant power that exceed 0.5 Watts may also cause skin burns.

- Limit laser use to Class 2 lasers.
- All lasers used must meet requirements set forth by the US Food and Drug Administration's (FDA) Center for Devices and Radiological Health.
  FDA Laser Pointer Advisory 2015
  Illuminating the Hazards of Powerful Laser Products
- Class 3B and Class 4 lasers must be registered with EH&S and the Campus Non-Ionizing Radiation Committee (NIRC). In addition, before these lasers may be put into operation, an approved Laser Use Authorization from the NIRC must be obtained.
- Post signs that say, "WARNING: Laser and/or strobe lights are used during this performance."
- Keep laser beams and reflected beams above the spectators' heads and out of audience's reach.
- Do not use hand held mirrors to deflect laser beams as they are difficult to control. They can direct beams in unexpected ways potentially causing eye damage.
- Ensure that any item with a reflective surface does not come into contact with the laser beam.
- Higher power un-scanned laser beams, such as those projected by beam tables or reflected from bounce mirrors, are to be separated from the audience by three (3) meters vertically and 2.5 meters laterally.
- To eliminate the risk of skin burns, do not insert any body parts into a Class 3B or Class 4 laser beam.
- Prevent electric shocks, but not accessing live electrical components. Do not service high voltage equipment. Only a qualified electrician may service electrical systems and equipment.

Appendix A

Laser Pointer Advisory

Laser Pointer Safety
Fact Sheet and Advisory

A Real Danger

Commercial laser pointers have become common tools in the workplace. Most often, laser pointers are used as a substitute for the retractable metal pointer used during lectures or presentations.

"Even momentary exposure from a laser pointer can cause discomfort and temporary visual impairment, "warns the American Optometric Association (AOA). "There can be glare, similar to that encountered with oncoming headlights at night; flash blindness, such as from a flashbulb; and afterimages, which involve the perception of spots in the field of vision."

"Flash blindness and afterimages may last for several minutes. If afterimages persist for several hours, or if a disturbance in vision is apparent, an eye examination should be performed to determine if there is any permanent eye damage."

(source: Texas Workers' Compensation Commission)

1. COSE Policy

All laser pointers used for seminar or classroom presentations must be used according to this advisory. The COSE allows the use of laser pointers with hazard classifications of 2 and 3A/R without registration or prior approval. Class 3B or Class 4 laser pointers may not be used for teaching or research unless registered and approved by the COSE Non-Ionizing Radiation Committee (NIRC)

2. Rationale

In Class 2 pointers, power output is less than 1 mW; the human blink reflex is sufficient to provide protection. Class 3A(3R) laser pointers are safe for momentary viewing, but they are a recognized eye hazard when viewed through optics. Their power output is between 1 and 5 mW. The US allows the sale of laser pointers under 5 mW.

Most laser pointers are Class 3A/R in the 640-650 nm range. The human eye is more responsive to these wavelengths than to the 690 nm wavelength of the earlier laser pointers.

3. Green Pointers

This pointer is a frequency-doubled Nd:YAG lasers. The output beam is 532 nm, with a blocked infrared beam at 1,064 nm. These pointers are exceptionally bright to the human eye; for safety, it is critical that the invisible 1,064 nm beam-blocking filter be in place. They are not any more hazardous, but have received complains of eye strain due to their perceived brightness.

4. How to Protect Yourself and Others

When used as intended, these devices do not present a hazard to the user or to members of the audience. It is important to make sure the laser pointers used in seminars are Class 2 or 3A/R as these rarely cause serious, long-term injuries.

Source of the above information is courtesy of Lawrence Berkeley National Laboratory.

To ensure safety, follow these safe practices:

- When buying a laser pointer, choose one that has that operates between 630 nm-680 nm and a maximum output of < 5mW. It should say Class 2 or 3A/R.
- Do not purchase a laser pointer if it does not have a CAUTION or DANGER sticker on it identifying the class. Report suspicious devices to the Food and Drug Administration (FDA).
- Do not intentionally stare into the laser beam.
- Do not intentionally aim the pointer beam at oneself or another person, particularly in the face.
- Direct the beam toward the screen and away from the audience.
- Turn the beam off when not in use.
- Choose a laser pointer that stays on only when you apply pressure with your fingers.
- Do not point the laser beam at mirror-like surfaces that reflect the light back.
- Never view a laser pointer using an optical instrument, such as binocular or a microscope.
- Do not leave laser pointers where children or students can "borrow" them without permission or without appropriate supervision.

5. Legal implications of Laser Pointer Misuse

The California Penal Code has several sections that state that misuse of a laser pointer can be considered a misdemeanor or felony. In particular, directing any laser beam at another person may constitute assault *(suggesting the use of a laser gunsight)* and directing any laser beam at an aircraft may constitute malicious mischief. These actions can result in fines and or jail sentences. Do not laser pointers that are not properly labeled as required by FDA.

6. Labeling of Pointers

The pointer manufacturer is required by federal law (21 CFR Part 1040) to have a warning label on the pointer. The label must show the laser hazard symbol, laser classification, laser wavelength, and maximum power output. Class 3A/R pointers MUST have a laser warning label. If there is no label, it was likely manufactured in countries where US FDA safety requirements are not met or required.

7. Emergencies

Although the potential for injury from a standard laser pointer is low, notify your supervisor and get medical attention if you suspect an injury to the eye.

Call Student Health Services, ext. 8-2754 during regular business hours or Campus Police, x8-2222 or 911 24 hours per day. From mobile phones, call 415.338.2222 for faster response.

College of Science & Engineering
Laser Safety Officer
Office: 415.338.6892
E-mail: lvadura@sfsu.edu

Appendix B

Laser Use Authorization Form

Environment, Health & Safety
Laser Safety Officer
Tel: 415/338-6892
Fax: 415/338-6136
SF STATE

Laser Safety Program

Laser Use Authorization Form: L-01

Part I – Laser Registration

NOTE: All lasers of Class 3B and Class 4 must be registered with the Environment Health and Safety Office and Non-Ionizing Radiation Committee (NIRC).

- Please complete this form for each Class 3 B or 4 laser you plan to acquire (or already have) and email to both safety@sfsu.edu and sfehs@sfsu.edu.
- An email confirmation will be sent to the applicant within seven days of receipt of Part I: Laser Registration.
- NIRC approval is required before putting laser into operation. Allow 30 days from receipt of completed LUA application, Part I and Part II.

Section A: Laser Holder and General Information					
Principal Investigator:					
Office Phone No:		E-mail address:			
Laser Operator(s): (Check all that apply)	☐ Paid Staff/Faculty	☐ Enrolled students	☐ Volunteer Employees	☐ Visitors	
Laser Manufacturer:			☐ SFSU Fabricated Laser		
Model Number:		Serial Number:		SFSU Property #	
Type of Laser Equipment:					
Type of Registration	☐ New Laser/laser system acquisition or installation ☐ Alteration/transfer/status change of an existing laser system* (Explain in *Comments* section below.)				

Section B: Location and Laser Details					
Department:		Building:		Room Number:	
Laser Classification (Check One):	☐ **Class 3B** (5-500 mW) or (≤ 125 mJ pulsed)		☐ **Class 4** (>500 mW) or (> 125 mJ pulsed)		
Active Medium (i.e., Argon, Ruby, Nd:YAG, Diode):					
Tunable Laser? (Check One)	☐ Yes ☐ No	*Details*			
Wavelength(s) (nanometers):					
Beam Divergence	**mrad**				
Beam Diameter at laser output:	**mm**				
Purpose and Frequency of Use: → ☐ Research ☐ Classroom					
☐ Continuous Wave	Average Power (W):		Maximum Power (W)		
☐ Repetitively Pulsed	Energy per Pulse (J)		Pulse repetition frequency (Hz)		
☐ Single Pulse	Pulse duration (nsec)		Pulse width (s)		
☐ Q-Switched	Peak Pulse Power (W)		Peak Power Density (W/cm²)		

Please check all items that apply to your operation:

☐ Invisible Beam (IR or µv)	☐ High Voltage (660V)	☐ Multi-Use Room	☐ Public Theater
☐ Exposed Beam Path	☐ Beam Focusing Optics	☐ Outdoor use	☐ Creative Arts
☐ SFSU Modified Laser	☐ Frequency-doubling Crystal	☐ Laser Cutting/Welding	☐ 3-D Printer

Comments

Laser Use Status ☐ Ready to Use ☐ In Storage (useable, stored) ☐ Needs Repair (not useable)

PI Signature: _____ Date: _____

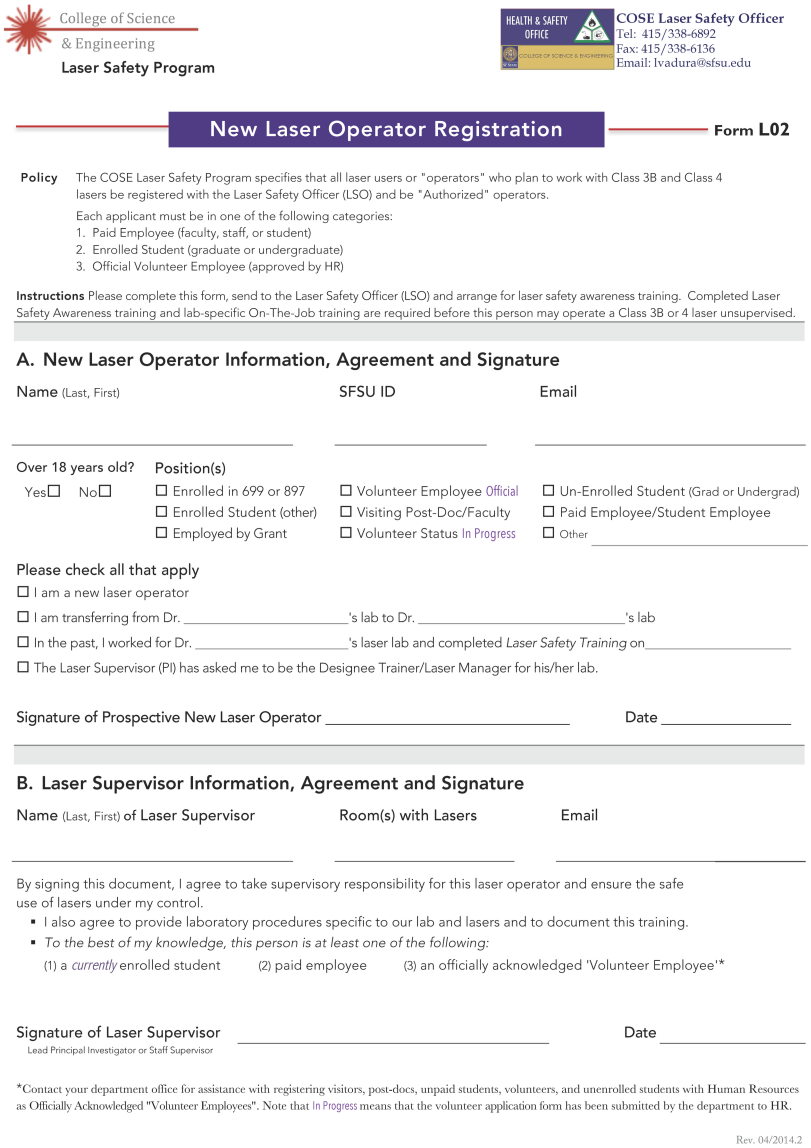
By manually signing this form or printing my name electronically, I acknowledge that all statements are true and accurate. If requested, an actual signed document can and will be provided.

*Alterations include any changes(s) that substantially increases or decreases the output or wavelengths produced. Relocation from one work space to another or transfer to a new owner is also an "alteration".

Edit Date:10/31/18

Appendix C

Laser Operator Registration and Training



College of Science & Engineering
Laser Safety Program

HEALTH & SAFETY OFFICE
COSE Laser Safety Officer
Tel: 415/338-6892
Fax: 415/338-6136
Email: lvadura@sfsu.edu

New Laser Operator Registration — **Form L02**

Policy The COSE Laser Safety Program specifies that all laser users or "operators" who plan to work with Class 3B and Class 4 lasers be registered with the Laser Safety Officer (LSO) and be "Authorized" operators.

Each applicant must be in one of the following categories:
1. Paid Employee (faculty, staff, or student)
2. Enrolled Student (graduate or undergraduate)
3. Official Volunteer Employee (approved by HR)

Instructions Please complete this form, send to the Laser Safety Officer (LSO) and arrange for laser safety awareness training. Completed Laser Safety Awareness training and lab-specific On-The-Job training are required before this person may operate a Class 3B or 4 laser unsupervised.

A. New Laser Operator Information, Agreement and Signature

Name (Last, First) _____ SFSU ID _____ Email _____

Over 18 years old? Yes☐ No☐

Position(s)
☐ Enrolled in 699 or 897 ☐ Volunteer Employee Official ☐ Un-Enrolled Student (Grad or Undergrad)
☐ Enrolled Student (other) ☐ Visiting Post-Doc/Faculty ☐ Paid Employee/Student Employee
☐ Employed by Grant ☐ Volunteer Status In Progress ☐ Other _____

Please check all that apply
☐ I am a new laser operator
☐ I am transferring from Dr. _____'s lab to Dr. _____'s lab
☐ In the past, I worked for Dr. _____'s laser lab and completed *Laser Safety Training* on _____
☐ The Laser Supervisor (PI) has asked me to be the Designee Trainer/Laser Manager for his/her lab.

Signature of Prospective New Laser Operator _____ Date _____

B. Laser Supervisor Information, Agreement and Signature

Name (Last, First) of Laser Supervisor _____ Room(s) with Lasers _____ Email _____

By signing this document, I agree to take supervisory responsibility for this laser operator and ensure the safe use of lasers under my control.
- I also agree to provide laboratory procedures specific to our lab and lasers and to document this training.
- *To the best of my knowledge, this person is at least one of the following:*
  (1) a *currently* enrolled student (2) paid employee (3) an officially acknowledged 'Volunteer Employee'*

Signature of Laser Supervisor
Lead Principal Investigator or Staff Supervisor _____ Date _____

*Contact your department office for assistance with registering visitors, post-docs, unpaid students, volunteers, and unenrolled students with Human Resources as Officially Acknowledged "Volunteer Employees". Note that In Progress means that the volunteer application form has been submitted by the department to HR.

Rev. 04/2014.2

COSE *Laser Safety Program* Form: **L04**

Record of Operational (On-The-Job) Laser Training

Laser Program Note:
To be an Authorized User, the following documents are required:

A. New Laser Operator Registration (*Form* L02)
B. Laser Safety Awareness Training with LSO (*Form* L03)
C. Operational On-The-Job Laser Training

Instructions:

Who: **Laser Lab Supervisor** (i.e., Principal Investigator)*

What: Provides training to his/her Class 3b and 4 lasers in the following topics:
- How to operate the laser system(s) the person is authorized to use
- How to set up the experiments correctly and with the appropriate safety precautions
- How to use, store, and wear the appropriate eye protection for alignments and as needed.

When: Complete and provide this ***OTJ Training Record*** to LSO within **90 days** of the initial laser safety orientation and before allowing unsupervised work using the Class 3b or 4 laser(s) in the lab.

A. Name of New Laser Operator

First Name MI Last Name

Date of Initial Laser Training

Laser Safety Awareness Training with LSO

B. On-The-Job Training Details

Procedures Covered	Date of Training	Initials Laser User	Initials Trainer
Start-up / Shut-down			
Alignment			
Eyewear Use and Care			
Security/Access			
other			

Laser Lab Supervisor

I have provided my students and employees with the knowledge they need to safely work with the laser(s) located in room(s) _____

(Please Print)
Supervisor Name: _____

*Signature of Laser Supervisor

Laser Operator

1. I acknowledge that I have received operational training in safely using the laser(s) in my work area.
2. I know that I am responsible for following the established safety protocols and laboratory operating procedures that allow me to work safely and effectively with these laser systems.

Signature of Laser Operator

Appendix D

Laser Safety for Theater and Creative Arts

Under Construction

Laser Safety for Theater and Creative Arts

San Francisco State University
Campus Non-Ionizing Radiation Committee

Appendix E

Review and Amendment Log

Appendix E—Review and Amendment Log

Date	Amendments	Pages/Sections	Initials
07/29/2019	Removed COSE Health & Safety Office from headers. Added 12.2 Servicing Class 1 Laser Equipment	Section 12, Class 1 Laser System	LEV