CALIFORNIA STATE UNIVERSITY, FRESNO

LASER SAFETY MANUAL

Office of

Environmental Health and Safety

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California State University Fresno
Laser Safety Manual

SECTION 1
Introduction

A. Program Intent

The Laser Safety Program is intended to provide staff, researchers, students and visitors with a safe laser use environment. The manual was written to provide laser safety policy and guidance on maintaining and documenting the program. The manual also serves as a reference source for laser users.

B. Regulatory Requirements

Regulation of laser hazards fall under the California Code of Regulations (CCR), Title 8, Subchapter 7 General Industry Safety Orders, Section 3203 (Injury and Illness Prevention Program). Section 3203 requires that every employer "...include a system for ensuring that employees comply with safe and healthy work practices..." Enforcement of the regulations falls to the California Occupational Safety and Health Administration (CAL-OSHA). At this time, CAL-OSHA has not developed specific laser safety regulations, but they train their inspectors in the ANSI Z136.1 - 2007 Standard for the Safe Use of Lasers as the accepted "...safe and healthy work practice..." to use in inspecting laser facilities.

C. ANSI Z136.1 - 2007 Standard for the Safe Use of Lasers

The Laser Safety Program is based on the ANSI Z136.1 - 2007 Standard for the Safe Use of Lasers. Copies of the standard are available from the Office of Environmental Health & Safety, Risk Management and Sustainability (EH&S/RMS).

D. Program Authority

The Laser Safety Program was developed in accordance with the campuswide Illness and Injury Prevention Program. The policies set forth in this manual were developed and approved by EH&S/RMS. The campus Laser Safety Officer (LSO) is responsible for the implementation of the Laser Safety Program.

SECTION 2
Laser Safety Program

A. Responsibilities and Program Administration

Laser Safety Officer

The Laser Safety Officer (LSO) is responsible for the day to day program implementation, and compliance. The LSO works with the Office of Environmental Health and Safety to set laser safety policy and is responsible for laser safety policy enforcement. The LSO is required to classify all constructed or modified laser systems, review and file all LRFs, investigate laser incidents, and maintain all records associated with the Laser Safety Program.

Office of Environmental Health and Safety

The Office of Environmental Health & Safety, Risk Management and Sustainability shall set campuswide laser safety policy and have the final authority in assuring that all lasers on campus are operated in a safe manner. The Office of EH&S/RMS is responsible for providing resources to assist the LSO in program implementation.

Department Chairs

Department chairs are responsible for assuring their laser using PIs operate those lasers safely and implement the Laser Safety Program.

Principal Investigators

Principal Investigators (PIs) are directly responsible for implementing the Laser Safety Program. This includes the implementation of specified hazard controls, oversight and management of non-laser hazards, and informing the LSO of any changes which affect the laser users. It is also the responsibility of the PI to assure that all laser users operating under his or her project have met the training requirements.

Laser Users

Laser users are responsible for their own safety in the laser facility. All users must meet the laser safety training requirement within 30 days of joining the project. All laser users are responsible for following the specific hazard controls and notification requirements.

B. Scope of the Program

The Laser Safety Program primarily addresses Class 3B and 4 lasers. All lasers of these classes, excepting laser pointers, must have Laser Registration Forms (LRFs) filed, which describe the laser, its use, hazard class, and any associated laser safety measures. Laser pointers are covered under Appendix D. The LRF file is maintained by the LSO.

C. Acquisition, Modification, Sale or Transfer of Lasers

The LSO must be informed of the acquisition, modification, sale, or transfer of Class 3B or 4 lasers. The procurement office normally supplies the LSO with copies of laser purchase order documents. However, it is the responsibility of the PI to inform the LSO whenever acquisition, modification, sale, or transfer of a laser or laser system occurs.

D. The Laser Registration Form (LRF)

A Laser Registration Form (Appendix A) must be filed with the LSO prior to any use of a Class 3B, or 4 laser on campus. The LRF will specify the manufacturer, model, class, type and power output of the laser, as well as the use and/or storage location, the name of the PI and any other such person(s) responsible for the laser, and a short description of the intended use for the laser, as well as any possible safety considerations. The LSO must be notified of any changes in the information provided on the LRF.

E. Laser Safety Training

All laser users, where appropriate, must read the Laser Safety Training Guide and fulfill any other specific safety training requirements. It is the responsibility of the PI to ensure that all users complete the required safety training. Formal laser safety training presentations are available from the LSO upon request. The LSO may direct a PI to obtain this training for his/her users. The LSO maintains documentation on all formal training presentations. The PI shall also, where necessary, provide and document that all laser users operating under his/her project have received specific hands-on instruction in use of the laser system, safety precautions associated with the laser, any SOPs relating to the laser, and proper use of laser protective eyewear.

F. Laser Safety Inspections

Periodically, all laser facilities are inspected by the LSO to assure that the laser is being operated in a safe manner. Copies of any recommended safety corrections are provided to the PI for his/her action. The PI is responsible to correct unsafe conditions. The LSO will inform EH&S of any uncorrected unsafe conditions.

G. Eye Examinations

Laser eye exams may be required for Class 3B and 4 laser users depending on the circumstances of the laser use. Additionally, laser eye exams may be required after any actual or suspected eye injury. The University Health and Psychological Services Center, Saint Agnes Occupational Health Center or such other designated health provider will determine the content of the examinations and will maintain records of any eye exams performed. See Appendix C for more information.

H. Personal Protective Equipment

The PI shall provide his/her laser users with appropriate laser protective eyewear whenever necessary. Protective eyewear must be used for beam alignments if the viewed beam exceeds the ANSI Z136.1 – 2007 MPE (maximum permissible exposure) value. Intrabeam viewing of lasers is not allowed. Some UV laser uses may require skin protection. Any needed skin protection will be provided by the PI. Criteria for selection of protective eyewear is discussed in Appendix B.

I. Beam Management

Laser beams must be restricted to the immediate location of use. Beams should be enclosed whenever practical. Beam blocks must be used to terminate beams. The use of shutters, collimators, curtains, and other beam control devices is strongly encouraged. It is the responsibility of the PI to assure that appropriate beam management is being practiced.

J. Posting and Labeling

All access points to the laser facility must be marked with ANSI standard laser hazard signs. Laser enclosures must be labeled to alert users to laser hazards as per the ANSI standard. Labels and laser hazard signs are available from the LSO. See Appendix E for examples of laser hazard signs.

K. Access Control

Whenever the laser is in operation, access to laser facilities is restricted to laser users or persons being escorted by laser users. Access control must be maintained by positive means such as locked doors. Laser warning signs alone are not considered sufficient to control access.

L. Laser Incidents

The LSO and PI must be informed immediately of any suspected laser incidents. Following the incident, the PI is responsible for filing the appropriate report of injury form. The LSO is responsible for investigating laser incidents, providing a report to the PI and EH&S/RMS, and maintaining records on incidents. See Appendix F for laser accident emergency procedures.

SECTION 3

Laser Hazard Classification

A. Determining Hazard Class Through Radiometric Parameters

The hazard class of the laser is extremely important in determining the appropriate hazard controls to make the laser system safe. The LSO assures that all lasers are properly designated as to their appropriate hazard class. All commercially manufactured lasers come marked with the hazard class as required under the FDA Center for Devices and Radiological Health (CDRH) regulations. Lasers manufactured or modified on campus will need to be evaluated by the LSO and appropriately classed. It is the responsibility of the PI to assist the LSO by supplying the appropriate radiometric parameters of the laser system. The LSO uses the ANSI Z136.1 – 2007 standard to determine the appropriate hazard class. See Appendix H for information on hazard classes for typical lasers.

B. Class 1 and 1M (Eye Safe Lasers)

Class 1 lasers are lasers which cannot cause injury from viewing the accessible laser radiation for the maximum possible duration inherent in the design; provided the maximum duration does not exceed 30,000 seconds. Very few lasers are Class 1, however many laser systems can be made into Class 1 systems by totally enclosing the laser beam and interlocking the enclosure. Class 1M lasers are those which it is possible to exceed the Class 1 standard when viewed with optical aids. Class 1 lasers do not require a LRF.

C. Class 2 and 2M (Safe Through the Aversion Response)

Class 2 lasers are defined as visible lasers that will not cause injury to the eye when viewed for 0.25 seconds or less. The human aversion response (blinking or turning away from the beam) is triggered by the bright glare of the visible beam entering the eye, and is estimated to occur in no more than 0.25 second. Eye injury can occur if collecting optics are used in viewing the beam or if an individual overrides the aversion response and continues to stare into the beam path. As with all lasers, DO NOT LOOK INTO THE BEAM. Class 2 lasers may not exceed a radiant power of 1 mW. Class 2M lasers are those which it is possible to exceed the Class 2 standard when viewed with optical aids. Class 2 lasers do not require a LRF, Class 2M lasers may be required to have an LRF depending on the conditions of use.

D. Class 3R and 3B (Intrabeam/Specular Reflection Hazard)

Class 3 lasers are defined as lasers which may cause injury through intrabeam viewing or through viewing a specular reflection for less than 0.25 second. Viewing a diffuse reflection from a Class 3 laser generally will not cause injury to the eye. Class 3R lasers are defined as; an invisible laser with a radiant power which does not exceed 5 times the Class 1 AEL or a visible laser with a radiant power which does not exceed 5 mW. Class 3B lasers exceed the radiant power of Class 3R lasers but cannot exceed the upper power limit of 500 mW. Class 3R lasers may be required to have an LRF depending on the conditions of use, all Class 3B lasers require LRFs.

E. Class 4 (Diffuse Reflection and Fire Hazard)

Class 4 lasers possess the same hazards as Class 3B lasers but, because of their increased beam power (greater than 500 mW), they may also cause injury to the eye when viewing a diffuse reflection. They may present a hazard to the skin and because of their power density, they may also present a laboratory fire hazard. All Class 4 lasers require LRFs.

Section 4
Appendices

Appendix A
LASER REGISTRATION FORM (LRF)
(Please complete a form for each Class 3B or 4 laser)

Date: _____

Name of Principal Investigator: _____

Phone No: _____ Office No. _____ Dept.: _____

Names of Laser Users: _____

_____

_____

Building and Room Location of Laser Use: _____

Laser Storage Location (if different from above): _____

Make/Model of Laser: _____

Laser Serial Number: _____

Type of Lasing Medium: _____

LASER INFORMATION

Laser Classification Marked on Laser (circle one): 3B 4 none

C W

Wavelength(s): _____(nm)
Max. Op. Power: _____(W)
Avg. Op. Power: _____(W)

Pulsed

Wavelength(s): _____(nm)
Pulse duration: _____(sec)
Pulse frequency: _____(Hz)
Max. Op. Energy: _____(J)
Avg. Op. Energy: _____(J)

Beam diameter at aperture: _____(mm)
Beam divergence: _____(mrad)

Laser Use (describe briefly): _____

_____

_____

_____

Safety Considerations (describe briefly): _____

_____

_____

_____

Appendix B
Selection of Laser Safety Eyewear
ANSI Z136.1 - 4.6.2.4

The following factors shall be considered in selecting the appropriate laser protective eyewear to be used:

1. Laser power and/or pulse energy.
2. Wavelength(s) of laser output.
3. Potential for multiwavelength operation.
4. Radiant exposure or irradiance levels for which protection (worst case) is required.
5. Exposure time criteria.
6. Maximum permissible exposure (MPE)
7. Optical density requirement of eyewear filter at laser output wavelength.
8. Angular dependence of protection afforded.
9. Visible light transmission requirement and assessment of the effect of the eyewear on the ability to perform tasks while wearing the eyewear.
10. Need for side-shield protection and maximum peripheral vision requirement.
11. Radiant exposure or irradiance and the corresponding time factors at which laser safety filter characteristics change occurs, including transient bleaching especially for ultrashort pulse lengths.
12. Need for prescription glasses.
13. Comfort and fit.
14. Degradation of filter media, such as photobleaching.
15. Strength of materials (resistance to mechanical trauma and shock).
16. Capability of the front surface to produce a hazardous specular reflection.
17. Requirement for anti-fogging design or coatings.

Appendix C

Laser Eye Examination Policy and Procedure

Statement of Policy

Laser eye examinations may be performed to identify those laser users which may have a predisposition for vision related injury and to meet the medical monitoring requirements of the ANSI Z136.1 – 2007 Standard for the Safe Use of Lasers.

Requirement for Examinations

Those laser users who have a significant potential of eye exposure to Class 3B or Class 4 laser beams may be required to have eye examinations depending on the circumstances of the laser use. Eye examinations may also be performed whenever a laser eye injury occurs or is suspected.

Responsibilities

The Office of Environmental Health & Safety, Risk Management and Sustainability is responsible for developing and periodically reviewing the laser eye examination policy. EH&S/RMS shall also maintain a database of laser users eye examinations.

The Laser Safety Officer (LSO) is responsible for implementing the laser eye examination policy. The LSO and the Principal Investigator (PI) are responsible for identifying those laser users who need to have examinations.

The PI is responsible for assuring that laser users identified as needing examinations make appointments either through the University or with their own physician. PIs are not responsible for costs associated with examinations performed outside of the University.

Laser users are responsible for making and attending appointments with either the University Health and Psychological Services Center, Saint Agnes Occupational Health Center or such other designated health provider, or with their own physician. Examinations performed by private practitioners are the financial responsibility of the laser user.

Eye Examination Criteria

The content of eye examinations is determined by the University Health and Psychological Services Center, Saint Agnes Occupational Health Center or such other designated health provider, or the private practitioner, but should normally include the following:

Medical history of the eye and photosensitivity
Visual acuity (far and near) for both eyes
Macular function (Amsler grid)
Color vision assessment
Dilated retinal examination of both eyes
Retinal photographs of both eyes (while dilated)

Examinations will be performed by professionally qualified personnel. Patients whose results fall outside of acceptable criteria will be referred for a comprehensive examination.

Records

The University Health and Psychological Services Center, Saint Agnes Occupational Health Center or such other designated health provider will inform the LSO of the names and dates of laser users receiving examinations. If the examination is performed by a private practitioner, it is the responsibility of the user to inform the LSO.

Medical records of examinations performed by the University Health and Psychological Services Center, Saint Agnes Occupational Health Center or such other designated health provider and any records returned from private practitioners are maintained by the University Health and Psychological Services Center or Saint Agnes Occupational Health Center. It is the responsibility of the person examined to see that any necessary records of examinations by private practitioners are forwarded to the proper health care provider. Results of examinations become the property of the proper health care provider and the person examined. Results of examinations are confidential except that EH&S/RMS will be notified if an examinee did not meet acceptable criteria.

The Office of Environmental Health & Safety, Risk Management and Sustainability will maintain a database of laser users and the dates on which they received any examinations.

Appendix D

Laser Pointer Safety Guidelines

Applicability

All Class 2 or 3R laser pointers used for class room instruction or presentations shall be operated under the guidelines established in this document. It is not required to file a Laser Registration Form for Class 3R laser pointers. These guidelines are not applicable to any Class 3B and 4 laser devices, nor shall such devices be used in instruction or presentations without prior notification of the Laser Safety Officer.

Rationale

By definition, a Class 3R laser can cause eye injury. However, the intended use of laser pointers carries a very low probability of injury. For this reason, EH&S has approved the use of Class 3R pointers for their intended use as instruction and presentation aids.

Labeling of Pointers

The manufacturer is required by the FDA Center for Devices and Radiological Health (CDRH) to provide correct labeling for their laser pointers. This includes the laser hazard symbol, laser classification, maximum power output and laser wavelength. This information should be clearly visible on the laser pointer. Operating and safety instructions should also be provided by the manufacturer.

If the laser is fabricated in-house or does not have the required labeling, contact the Laser Safety Officer (LSO) before using the pointer. The LSO will classify and provide labels for the pointer.

Equipment Purchase Considerations

If possible, purchase a Class 2 laser pointer (power does not exceed 1 mW). Class 2 lasers are designed to be safe if the beam accidentally enters the eye for a short period. The aversion response (blinking or turning the head) is fast enough to prevent injury.

The operating switch should be a momentary contact type (designed to shut off the pointer when released). The switch should not have a locking device to keep the beam on when direct pressure is removed from the switch. Pulsed laser pointers shall not exceed the Class 3a hazard class.

Since the human eye perceives light at mid-range wavelengths more brightly, short and long wavelength lasers require more power to maintain the same brightness. For this reason, it may be better to purchase laser pointers that operate at wavelengths closer to the mid-range.

Authorized Users

University employees handling laser pointers on campus are required to follow these guidelines.

Access to laser pointers should be limited to responsible persons who have been informed of these guidelines by the owner or user. The laser pointer should be kept in a secure place when not in use.

Persons visiting the University who wish to operate laser pointers are expected to abide by these guidelines. Generally, the person acting as host should inform the visitor of these guidelines.

The owner of the laser pointer is responsible for its use at the University.

Operating Safety Guidelines

No person should ever intentionally stare into the laser beam.

The laser beam should never be intentionally directed toward oneself or directed toward another person. The beam should be directed towards the screen and directed away from the audience.

The beam should be turned off when not in immediate use.

Mirror like surfaces (such as glass, metal and other highly reflective materials) should be avoided when directing the laser beam.

Use of Class 3R laser pointers should be limited to the intended purpose. Indiscriminate use may present an eye hazard.

Class 3R laser pointer use is prohibited when optically aided viewing of the beam is probable. Optical aids include telescopes, binoculars, viewing optics, and similar devices.

Exceptions

Exceptions to the above guidelines should be coordinated with the Laser Safety Officer.

Legal Implications of Laser Pointer Misuse

The California Penal Code has several sections which indicate the willful misuse of a laser pointer can be considered either a misdemeanor or a 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. Persons convicted of these crimes may be subject to stiff fines and/or jail sentences.

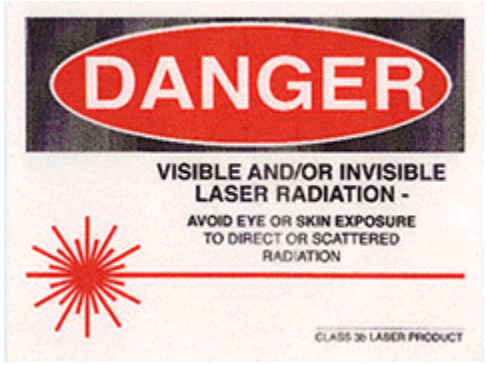
Emergencies

Although the potential for injury from a laser pointer is very slight, notify your immediate supervisor and get medical attention if an eye injury from laser use is suspected. Also notify the Laser Safety Officer @ 8-7394 as soon as possible. Contact the University Health and Psychological Services Center or Saint Agnes Occupational Health Center for emergency medical assistance.

Appendix E

Laser Hazard Signs

ANSI sign to mark doors to laser labs with Class 2 & 2M lasers.



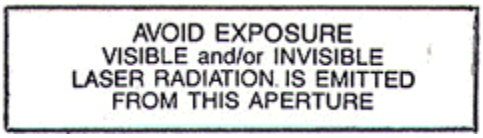
ANSI sign to mark doors to laser labs with Class 3R & 3B lasers.

Door sign to indicate laser alignment/maintenance.

Sticker to mark high voltage hazard power supplies and laser enclosures.

Sticker to mark laser enclosures.

ANSI sign to mark doors to laser labs with Class 4 lasers.



Sticker to mark apertures where laser light is emitted.

Appendix F

Emergency Procedure for Laser Accidents

In the event of a laser accident immediately do the following:

1) Shut down the laser system.

2) Provide for the safety of personnel (first aid, evacuation, etc.) as needed.

   NOTE: If a laser eye injury is suspected, have the injured person keep their head upright and still to restrict any bleeding in the eye. Laser eye injuries should be evaluated by a physician as soon as possible.

3) Obtain medical assistance for anyone who may be injured.

   Emergency Medical Assistance **911**
   University Health Service (non-urgent medical care) 8-2734
   Saint Agnes Occupational Health Center (non-urgent medical care) 450-7777

4) If there is a fire, leave the area, pull the fire alarm, and contact the University Police Department by calling 911. Do not fight the fire unless it is very small and you have been trained in fire fighting techniques.

5) Inform the Office of Environmental Health & Safety, Risk Management and Sustainability as soon as possible.

   During normal working hours:

   EH&S/RMS Office 8-7422
   Laser Safety Officer 8-7394

   Other than normal working hours, call 8-8400 to contact the University Police Department (they have an EH&S/RMS emergency call list).

6) Inform the Principal Investigator as soon as possible. If there is an injury, the PI must submit a report of injury to EH&S/RMS.

7) After an accident, do not resume use of the laser system until the Laser Safety Officer and/or EH&S/RMS has reviewed the incident.

Appendix G

Laser Applications Outside the Laboratory

Introduction

The use of a laser outside of a controlled area can present special hazards to the campus community and to the general public. This appendix addresses the control of any laser (Class 3B, or 4) used outside the normal laboratory environment. These applications may include: laser use for instructional purposes, laser research being performed outdoors, lasers used for telecommunications, and lasers used for entertainment or public viewing.

Applicability

Any laser system (Class 3B, or 4) used outdoors for instructional purposes, research projects or for telecommunication applications (excluding laser pointers) shall have a current Laser Registration Form (LRF) on file with the Laser Safety Officer. Specific SOPs for outdoor use of the laser system may also be required.

Any laser (Class 3B, or 4) used for entertainment, displays, demonstrations, or any related use intended for public viewing (indoors or outdoors) shall be operated in accordance with federal, state, local, and campus regulations or requirements.

All Class 3B, or 4 laser systems being used on University property must be used in accordance with the campus Laser Safety Program. Any variations from the Laser Safety Program must be approved by EH&S.

Procedures

The Principal Investigator (PI) shall inform the LSO of any lasers (excluding laser pointers) used outdoors for instructional purposes or research projects. Such laser uses will need to be noted on the LRF. The department Safety Coordinator will be responsible for informing the LSO of any indoor or outdoor telecommunication applications being pursued by that department. In both cases, the application and operation of the laser system(s) shall be evaluated by the LSO to ensure that appropriate safety measures are in place prior to operation.

The University Student Union, campus departments, or other officially recognized groups shall notify the LSO of any laser light show (indoor or outdoor) to be performed on University property. The LSO will request from the light show operators a copy of the CDRH required "Report on Laser Light Show Display" (or variance document) prior to the show. Upon receipt, the LSO shall review the description of the show and the operator's safety procedures. The LSO may require additional safety measures to assure the safety of the operators, performers, or audience.

Laser Safety Requirements - Outdoor Uses of Laser

- Meet any specified SOP safety requirements.
- The PI must ensure users are properly trained and meet the campus laser safety training requirements.
- The PI must ensure only authorized personnel are allowed to operate the laser.
- The PI must ensure the use of any required administrative/engineering controls.
- The LSO will, if necessary, establish a Nominal Hazard Zone (any area where the maximum permissible exposure (MPE) is exceeded). The NHZ must be posted and/or restricted as directed by the LSO.
- The PI must ensure that only trained personnel enter the NHZ, and that appropriate PPE (personal protective equipment) is issued and used.
- Laser beams shall not be directed toward structures, automobiles, aircraft, or other vehicles unless specifically included in the project procedures and approved by the LSO.
- The laser beam path shall not be maintained at eye level without LSO approval.
- Additional safety requirements as needed may be specified by the LSO.

Laser Safety Requirements - Laser Light Shows

- The CDRH and ANSI requirements specified by the LSO must be met.
- Any audience exposure to laser radiation must not exceed the ANSI Class 1 limit.
- Operators, performers, and employees must be able to perform their duties without having to directly view laser radiation exceeding the ANSI Class 1 limit, and without being exposed to laser radiation exceeding the ANSI Class 2 limit.
- All laser scanners (including mirror balls) must incorporate proper scanning safeguards.
- If the laser is not under continuous operator control, any Class 3B, or 4 level of laser radiation cannot be closer than 6 m vertically or 2.5 m horizontally from any standing surface or standing position where the audience may be located.
- If the laser is under continuous operator control, any Class 3B, or 4 level of laser radiation cannot be closer than 3 m vertically or 2.5 m horizontally from any standing surface or standing position where the audience may be located.
- An operator with an accessible control to terminate the beam if conditions become unsafe must be available.
- Additional safety requirements as needed may be specified by the LSO.

Policy Exceptions

Any exceptions to this policy must be approved by EH&S/RMS. Contact the LSO if you need exemption from this policy.

Emergencies

The potential for injuries from a laser light show/display is minimal if the operators observe the CDRH requirements. In the event that an individual suspects an eye injury, the operators of the laser system shall be notified immediately so that the laser beam(s) can be terminated. The event staff shall also be notified and medical attention shall be provided to the injured individual if needed. The LSO shall be informed as soon as possible should any laser injury be suspected.

Appendix H

Electrical Safety Guidelines for Laser Users

Laser systems and power supplies often may require thousands of volts and tens of amperes to operate. The electrical needs associated with laser use present inherent electrical safety hazards.

These hazards are normally mitigated by the engineering controls (enclosures, interlocks, grounding, etc.) built into the laser systems. However, if these engineering controls are defeated during tuning or maintenance, live contacts can be directly accessed. Contact with these may cause any number of adverse bioeffects, up to and including death by electrocution.

It is essential that laser users be aware of and protect themselves from the electrical hazards found in laser facilities. Good work practices should be followed at all times while operating and performing maintenance on laser systems.

- Work on electrical equipment should only be performed by "qualified" personnel (Cal-OSHA requirement). These personnel must be properly trained in electrical safety practices and procedures and must be approved by their department to work on electrical equipment. It is essential that you do not work on electrical equipment if you are unfamiliar with electrical devices or if you are untrained in electrical safety.

- Established Lockout/Tagout procedures to allow for the safe installation, service, maintenance, adjustment, or other handling of laser systems and other powered equipment should be followed at all times. These procedures apply whenever the unexpected energizing of the equipment or release of stored energy (such as from charged capacitors) could cause injury. Equipment which has the potential to be energized must be properly locked and/or tagged out in accordance with the campus procedure.

- If the equipment can only be serviced or adjusted while energized, special "energized work" procedures, testing equipment, special tools, and personal protective equipment may be required. Special controls such as: the use of ground fault circuit interrupter (GFCI); insulated tools; and/or trained stand-by personnel may also be required.

- All electrical hazards should be properly marked and/or labeled. Proper switching and grounding techniques must be learned and practiced. The Cal-OSHA required work clearances around energized panels must be maintained.

Appendix I

Laser Laboratory Visitor Policy

A laboratory visitor is any person who is present in the laboratory as an invited guest of any University employee or student researcher.

It is the policy of the University to require the same level of laser laboratory safety for all visitors as is required for laser users. All visitors are to be escorted by an authorized laser user.

It is the responsibility of the Principal Investigator to assure that his/her laser users are informed of, understand, and follow this visitor policy.

It is the responsibility of the visitor's laser user escort to provide the visitor with an appropriate safety orientation covering the hazards in the laser laboratory. The escort shall also provide appropriate safety equipment and require the visitor use the safety equipment.

It is the responsibility of the Principal Investigator to assure that persons who are not invited into the laser laboratory or who fail to follow directions regarding safety policy or the use of safety equipment are immediately escorted from the laser facility.

Although it is primarily the responsibility of the escort to provide a safe environment for laboratory visitors, consideration should be given to the following:

- Unless it is absolutely necessary to have the laser energized during the visit, it is recommended that all lasers and laser power supplies be turned off and the activation keys removed during the visit.

- Research environments can prove very hazardous to children. It is recommended that persons under the age of 14 not be allowed into any laboratory.

- It is recommended that any laser demonstration be conducted so that the laser beam is directed away from any visitor, regardless of the laser eye protection being used.

Appendix J
Table of Typical Laser Classes
ANSI Z136.1 - Table C1

Typical Laser Classification - Continuous Wave (CW) Small Source Lasers

Wavelength (μm)	Laser Type	Wavelength (μm)	Class 1* (W)	Class 2 (W)	Class 3** (W)	Class 4 (W)
Ultraviolet						
0.180 to 0.280	Neodymium: YAG (Quadrupled)	0.266 only	$\leq 9.6 \times 10^{-9}$ for 8 hours		> Class 1 but ≤ 0.5	> 0.5
	Argon	0.275			> Class 1 but ≤ 0.5	> 0.5
Ultraviolet						
0.315 to 0.400	Helium-Cadmium	0.325 only	$\leq 3.2 \times 10^{-6}$		> Class 1 but ≤ 0.5	> 0.5
	Argon	0.351,0.363	$\leq 3.2 \times 10^{-6}$		> Class 1 but ≤ 0.5	> 0.5
	Krypton	0.3507,0.3564	$\leq 3.2 \times 10^{-6}$		> Class 1 but ≤ 0.5	> 0.5
Visible						
0.400 to 0.700	Helium-Cadmium	0.4416 only	$\leq 4 \times 10^{-5}$	> Class 1 but	> Class 2 but ≤ 0.5	> 0.5
	Argon	0.457	$\leq 5 \times 10^{-5}$	$\leq 1 \times 10^{-3}$	> Class 2 but ≤ 0.5	> 0.5
		0.476	$\leq 1 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
		0.488	$\leq 2 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
		0.514	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Krypton	0.530	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Neodymium: YAG (Doubled)	0.532	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Helium-Neon	0.543	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Dye	0.400-0.500	$\leq 0.4\ C_B \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Helium-Selenium	0.460-0.500	$\leq 0.4\ C_B \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Dye	0.550-0.700	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Helium-Neon	0.632	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	InGaAlP	0.670	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Ti:Sapphire	0.670	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
	Krypton	0.6471,0.6764	$\leq 4 \times 10^{-4}$		> Class 2 but ≤ 0.5	> 0.5
Near Infrared						
0.700 to 1.400	GaAlAs	0.780	$\leq 5.6 \times 10^{-4}$		> Class 1 but ≤ 0.5	> 0.5
	GaAlAs	0.850	$\leq 7.7 \times 10^{-4}$		> Class 1 but ≤ 0.5	> 0.5
	GaAs	0.905	$\leq 9.9 \times 10^{-4}$		> Class 1 but ≤ 0.5	> 0.5
	Neodymium: YAG	1.064	$\leq 1.9 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Helium-Neon	1.080	$\leq 1.9 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
		1.152	$\leq 2.1 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	InGaAsP	1.310	$\leq 1.5 \times 10^{-2}$		> Class 1 but ≤ 0.5	> 0.5
Far Infrared						
1.400 to 10^3	InGaAsP	1.550	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Holmium	2.100	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Erbium	2.940	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Hydrogen Fluoride	2.600-3.000	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Helium-Neon	3.390 only	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Carbon Monoxide	5.000-5.500	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Carbon Dioxide	10.6	$\leq 9.6 \times 10^{-3}$		> Class 1 but ≤ 0.5	> 0.5
	Water Vapor	118	$\leq 9.5 \times 10^{-2}$		> Class 1 but ≤ 0.5	> 0.5
	Hydrogen Cyanide	337	$\leq 9.5 \times 10^{-2}$		> Class 1 but ≤ 0.5	> 0.5

* Assumes no mechanical or electrical design incorporated into laser system to prevent exposures from lasting to T_{max} = 8 hours (one workday); otherwise the Class 1 AEL could be larger than tabulated.

** See 3.3.3.1 for definition of Class 3R.

Table of Typical Laser Classes
ANSI Z136.1 - Table C2

Typical Laser Classification - Single-Pulse Small Source Lasers

Wavelength (μm)	Laser Type	Wavelength (μm)	Pulse Duration (s)	Class 1 (J)	Class 3B (J)	Class 4 (J)
Ultraviolet						
0.180 to 0.400	Excimer (ArF)	0.193	20×10^{-9}	$\leq 2.4 \times 10^{-5}$*	> Class 1 but ≤ 0.125	> 0.125
	Excimer (KrF)	0.248	20×10^{-9}	$\leq 2.4 \times 10^{-5}$*	> Class 1 but ≤ 0.125	> 0.125
	Neodymium: YAG Quadrupled (Q-sw)	0.266	20×10^{-9}	$\leq 2.4 \times 10^{-5}$*	> Class 1 but ≤ 0.125	> 0.125
	Excimer (XeCl)	0.308	20×10^{-9}	$\leq 5.3 \times 10^{-5}$*	> Class 1 but ≤ 0.125	> 0.125
	Nitrogen	0.337	20×10^{-9}	$\leq 5.3 \times 10^{-5}$*	> Class 1 but ≤ 0.125	> 0.125
	Excimer (XeF)	0.351	20×10^{-9}	$\leq 5.3 \times 10^{-5}$*	> Class 1 but ≤ 0.125	> 0.125
Visible						
0.400 to 0.700	Rhodamine 6G (Dye Laser)	0.450-0.650	1×10^{-6}	$\leq 1.9 \times 10^{-7}$	> Class 1 but ≤ 0.03	> 0.03
	Copper Vapor	0.510,0.578	2.5×10^{-9}	$\leq 1.9 \times 10^{-7}$	> Class 1 but ≤ 0.03	> 0.03
	Neodymium: YAG Doubled (Q-sw)	0.532	20×10^{-9}	$\leq 1.9 \times 10^{-7}$	> Class 1 but ≤ 0.03	> 0.03
	Ruby (Q-sw)	0.6943	20×10^{-9}	$\leq 1.9 \times 10^{-7}$	> Class 1 but ≤ 0.03	> 0.03
	Ruby (Long Pulse)	0.6943	1×10^{-3}	$\leq 3.9 \times 10^{-6}$	> Class 1 but ≤ 0.03	> 0.03
Near Infrared						
0.700 to 1.400	Ti:Sapphire	0.700-1.000	6×10^{-6}	$\leq 1.9 \times 10^{-7}$	> Class 1 but ≤ 0.03	> 0.03
	Alexandrite	0.720-0.800	1×10^{-4}	$\leq 7.6 \times 10^{-7}$	> Class 1 but ≤ 0.033	> 0.033**
	Neodymium: YAG (Q-sw)	1.064	20×10^{-9}	$\leq 1.9 \times 10^{-6}$	> Class 1 but ≤ 0.125	> 0.15
Far Infrared						
1.400 to 10^3	Erbium:Glass (Q-sw)	1.540	10×10^{-9}	$\leq 7.9 \times 10^{-3}$	> Class 1 but ≤ 0.125	> 0.125
	Co: Magnisium-Fluoride	1.8-2.5	80×10^{-6}	$\leq 7.9 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125
	Holmium	2.100	250×10^{-6}	$\leq 7.9 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125
	Hydrogen Fluoride	2.600-3.000	0.4×10^{-6}	$\leq 1.1 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125
	Erbium	2.940	250×10^{-6}	$\leq 5.6 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125
	Carbon Dioxide (Q-sw)	10.6	100×10^{-9}	$\leq 7.9 \times 10^{-5}$	> Class 1 but ≤ 0.125	> 0.125
	Carbon Dioxide	10.6	1×10^{-3}	$\leq 7.9 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125

* Assuming that both eye and skin may be exposed, i.e., 1.0 mm beam (area of limiting aperture = 7.9×10^{-3} cm^2).

** Class 3B AEL varies from 0.033 to 0.480 J corresponding to wavelengths that vary between 0.720 and 0.800 μm.