The Laser Safety Manual is intended to support the use of laser systems for instructional and research applications.

Laser Safety Manual

August 14, 2019

Approval

Signature: [signature] Date: 10/04/2019

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Annual Plan Review

Revision Date	Reviewer	Summary of Changes (if applicable)	Approved By:
October 18, 2018	M. DeSalvio	Program updates, modified roles and responsibilities and implemented new control measures.	
March 25, 2019	M. DeSalvio	Updated approval in alignment with E.O. 1039	
August 14, 2019	M. DeSalvio	Updated training links for employees.	

Article I. Introduction

Advances in laser technology have since allowed for the expanded use of lasers into many areas of industry, communications, research, the military and numerous medical applications. Eye safety is the number one concern for anyone working with or near a laser. Eye damage can literally occur in less than a blink of an eye. Though the injuries are rare, they are often permanent and 100% preventable. Injuries are most common during alignment by experienced users who fail to wear protective eyewear. Engineering controls are the preferred method of protection but cannot be relied on as the only means of protection. Protective eyewear may also be necessary especially during the alignment of a laser beam.

Section 1.01 Definitions

(a) **Class 1**: Does not emit laser radiation at known hazard levels. Users of Class 1 lasers are generally exempt from radiation hazard controls during operation and maintenance, but not necessarily during service. Most Class 1 industrial lasers consist of a higher-class laser enclosed in a properly interlocked and labeled protective enclosure.

(b) **Class 1M**: lasers cannot, under normal operating conditions, produce damaging radiation levels unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or a telescope (collimated beam). This may be due to a large beam diameter or divergence of the beam. Such lasers must be labeled.

(c) **Class 2**: Low-power visible lasers with wavelength of 400-700nm emit laser radiation above Class 1 levels and radiant power not above 1mW. The human aversion reaction to bright light will protect the person from this low level. Example: a supermarket laser scanner.

(d) **Class 2M**: lasers are low power lasers or laser system in the visible range (400 - 700 nm wavelength) that may be viewed directly under carefully controlled exposure conditions. Because of the normal human aversion responses, these lasers do not normally present a hazard, but may present some potential for hazard if viewed with certain optical aids.

(e) **Class 3A**: Intermediate-power lasers of any wavelength are only hazardous for intra-beam viewing. The continuous wave output power of a Class 3AB visible laser is between 1 to 5 mW. Some limited controls are usually recommended. Example: a helium-neon laser used in the construction industry.

(f) **Class 3B:** Moderate-power lasers in the visible spectrum (400-760nm) to near infrared. The continuous wave output power of a Class 3B laser ranges from 5 to 500 mW. Not generally a fire hazard and not capable of producing a hazardous diffuse reflection, except in instances of intentional staring at distances close to the diffuser. Specific controls are recommended.

(g) **Class 3R**: denotes lasers or laser systems potentially hazardous under some direct and specular reflection viewing condition if the eye is appropriately focused and stable, but the probability of an actual injury is small. This laser will not pose either a fire hazard or diffuse-reflection hazard. They may present a hazard if viewed using collecting optics. Visible CW (constant amplitude and frequency) HeNe lasers above 1 mW, but not exceeding 5 mW radiant power, are examples of this class.

(h) **Class 4**: High-power lasers. It is hazardous to view under any condition (directly or diffusely scattered). Potentially a fire hazard and a skin hazard! Significant controls are required for Class 4 laser facilities. Example: An Excimer laser operating in the ultraviolet.

(i) **Collateral and Plasma Radiation**: Radiation not associated with the primary laser beam which is produced by system components such as power supplies, discharge lamps and plasma tubes. This radiation may be in the form of X-rays, UV, visible, IR, microwave and radiofrequency (RF.) When high power pulsed laser beams (peak irradiance of 1012 W/cm2 or greater) are focused on a target, plasma is generated that may also emit collateral radiation.

(j) **Irradiance**: The amount of light or other radiant energy striking a given area of a surface.

(k) **Laser-Generated Air Contaminants (LGAC):** Air contaminants may be generated when Class 4 and some Class 3b laser beams interact with matter. The quantity, composition and chemical complexity of the LGAC depend on the target material, cover gas and beam irradiance. Materials such as plastics, composites, metals and tissues may release carcinogenic, toxic and noxious air contaminants. Ozone is produced around flash lamps and can build up with high repetition rate lasers. Special optical materials used for far infrared windows and lenses may also release hazardous air contaminants.

(l) **Lasing Media**: Can be solids, liquids, or gases. The type of medium dictates the wavelength of the laser beam. Some media can be manipulated to allow for tuning of the wavelength. Solid state media (polished crystal rods), gases or vapors (sealed in a glass tube), liquid dyes, and semiconductors (laser diodes) are all common lasing media. Halogen gases mixed with noble gases can combine in an excited state to create pseudo molecules called "excited dimers" or excimers. Excimer lasers emit laser radiation in the ultraviolet region of the spectrum. It is also possible to use an accelerated beam of free electrons as a lasing media. Free electron lasers (FEL) use a "wiggler" magnet to propagate photons from the electron beam.

(m) **Maximum Permissible Exposure**: (MPE) is the highest power or energy density (in W/cm2 or J/cm2) of a light source that is considered safe. It is usually about 10% of the dose that has a 50% chance of creating damage under worst-case conditions. The MPE is measured at the cornea of the human eye or at the skin, for a given wavelength and exposure time.

(n) **Optical Cavity:** Is required to provide the amplification desired in the laser and to select the photons which are traveling in the desired direction. As the first atom or molecule in the metastable state of the inverted population decays, it triggers via stimulated emission, the decay of another atom or molecule in the metastable state. If the photons are traveling in a direction which leads to the walls of the lasing material, which is usually in the form of a rod or tube, they are lost and the amplification process terminates. They may actually be reflected at the wall of the rod or tube, but sooner or later they will be lost in the system and will not contribute to the beam. If, on the other hand, one of the decaying atoms or molecules releases a photon parallel to the axis of the lasing material, it can trigger the emission of another photon and both will be reflected by the mirror on the end of the lasing rod or tube. The reflected photons then pass back through the material triggering further emissions along exactly the same path which are reflected by the mirrors on the ends of the lasing material. As this amplification process continues, a portion of the radiation will always escape through the partially reflecting mirror. When the amount of amplification or gain through this process exceeds the losses in the cavity, laser oscillation is said to occur. In this way, a narrow-concentrated beam of coherent light is formed.

(o) **PPE:** Personal protective equipment which, by virtue of the laser class being utilized will vary in levels of required protection.

(p) **Pumping system:** Imparts energy to the atoms or molecules of the lasing medium enabling them to be raised to an excited "metastable state" creating a population inversion. Optical pumping uses photons provided by a source such as a Xenon gas flash lamp or another laser to transfer energy to the lasing material. The optical source must provide photons which correspond to the allowed transition levels of the lasing material. Collision pumping relies on the transfer of energy to the lasing material by collision with the atoms (or molecules) of the lasing material. Again, energies which correspond to the allowed transitions must be provided. This is often done by electrical discharge in a pure gas or gas mixture in a tube. Chemical pumping systems use the binding energy released in chemical reactions to state.

(q) **Supervision:** Supervision shall be defined as one the following:

1) Direct supervision by the PI or other faculty member responsible for the lab and/or equipment
2) In the absence of the PI, student leaders can serve as designated lab safety leads and provide supervision to other students to maintain a safe work environment. Student leaders shall require additional training

Article II. Purpose

The purpose of this program is to ensure that California State Polytechnic University, Pomona maintains compliance with applicable federal, state, and local regulations affecting the use of lasers.

Article III. Scope

This program applies to all employees who are potentially exposed to lasers as defined in Article I as a result of their normally required duties. This plan shall apply to all laser diodes, elements and components that when assembled can result in an exposure that may cause injury.

Article IV. Responsibilities

Section 4.01 University Employees

Any employee who works in an environment where a potential contact with lasers is responsible for the following:

(a) Plan and conduct each operation in accordance with the University's Environmental Health and Safety policies;

(b) Use good judgment at all times;

(c) Understand and comply with all applicable EH&S programs. Report any significant problems arising from the implementation this manual, to their Supervisor or PI;

(d) Report all facts pertaining to every accident, incident and any action or condition that may exist that could result in an accident

(e) Attend scheduled education and training sessions;

(f) Ask questions when there is concern about unknown or potentially hazardous sessions;

(g) Understand the function and proper use of all personal protective equipment (PPE). Wear appropriate PPE and use approved control measures when required or necessary;

(h) Contact their Principal Investigator and/or EH&S if any of the above procedures are not clearly understood;

(i) Participate in medical monitoring program as required and obtain medical treatment if injured.

Section 4.02 Department Chairs and Department Heads

It is the responsibility of Deans, Directors, Department Chairs, and Department Heads to develop departmental procedures to ensure an effective compliance with University Environmental Health and Safety policies as they relate to operations under their control. Specific areas include employee and student education and training, identification and correction of unsafe conditions and record keeping.

Section 4.03 Managers, Supervisors and Principle Investigators (PI's)

(a) Read and comply with University Laser Safety procedures and this program.
(b) Be familiar with content of this program and laser safety procedures.
(c) Train all users about specific safe use of lasers. Training shall be documented.
(d) Provide adequate supervision of all laser users. Students shall not operate a laser while unsupervised.
(e) Notify EH&S of all laser users names for Class 3B and 4 Lasers.
(f) Comply with medical surveillance program and refer injured individuals to medical attention.
(g) Develop and maintain written standard operating procedures (SOP) for use of Class 3B and Class 4 lasers.
(h) Submit a copy of SOPs to EH&S. Notify EH&S of any changes in writing.
(i) Notify EH&S of any changes to enclosed laser systems.
(j) Post appropriate signage; ensure signage remains intact and adequate.
(k) Report accidents/injuries to supervisors and EH&S within 24 hours.
(l) Complete an accident investigation for accidents or near miss accidents.
(m) Complete and document inspections of Class 3A, 3B and/or 4 Lasers or Laser Systems, when the system is first installed/constructed, whenever changes are made and annually. The inspection form in Appendix B will be used to document this inspection and a copy provided to EH&S.

Section 4.04 Environmental Health and Safety (EH&S)

(a) It is the responsibility of EH&S to develop, monitor and manage compliance of the University's Environmental Health and Safety programs as they relate to Federal, State and Local Environmental Health and Safety regulation standards. Further responsibilities are outlined below:
(b) Provide consulting to administration personnel, Deans, Directors, regarding program compliance;
(c) Consulting on issues of hazard identification and evaluation; procedures for correcting unsafe conditions;
(d) Determining, and recommending appropriate control measures; and
(e) Administration of employee's information and training programs and employee medical monitoring

Section 4.05 Students

Students are expected to always adhere to safe and healthful work practices defined by written and oral campus and departmental safety and health guidelines. Students must also report any hazard that becomes known to them, to their instructors or other responsible parties. Failure to do so may result in the initiation of disciplinary measures.

Article V. Safety Measures

The requirements which follow may or may not be applicable for each type of laser installation. Because the laser hazard is related to the wavelength, intensity, and intended use of the laser, the requirements may be modified accordingly. For example, a class 4 laser placed into a properly constructed enclosed beam path system may be reclassified as class 1 or 2. The required safety measures would then be reduced.

For all lasers, use the minimum amount of laser radiation possible to accomplish the experimental objective. Adjust beam height so that it is at a level other than that of a seated or standing person.

DIRECT EXPOSURE OF THE EYE BY A LASER BEAM SHOULD ALWAYS BE AVOIDED WITH ANY LASER, NO MATTER HOW LOW THE POWER.

Section 5.01 Class 1 Laser

Control measures for class 1 laser systems are as follows:

(a) Control measures or warning labels are not required, although needless direct exposure of the eyes should be avoided.

Section 5.02 Class 2 Laser

Control measures for class 2 laser systems are as follows:

(a) An appropriate warning label must be placed on the housing.
(b) Do not stare into the beam or allow other persons to do so.
(c) No other warning signs necessary

Section 5.03 Class 3A, 3B Laser

Control measures for class 3A and 3B laser systems are as follows:

(a) The laser must have a protective housing such that laser light emerges from the aperture only.
(b) A Key switch interlock system will be used to prevent unauthorized use of the laser.
(c) The direct or mirror-reflected beam should not be viewed with the naked eye or with optical instruments such as telescopes.
(d) Do not align the beam with the naked eye.
(e) A beam stop must be provided to adequately stop the beam with the absence of scattered light emission.
(f) Laser goggles may be necessary. Be certain that the goggle in use is appropriate both in the attenuation factor provided by the goggle and that the goggle is for the proper wavelength. LASER GOGGLES MUST BE MATCHED TO THE WAVELENGTH OF THE LASER SYSTEM BEING USED! Be aware of the dangers that reflected lasers can pose. In addition to mirrors, many smooth surfaces can reflect lasers.
(g) Spectators must be limited. If present must wear appropriate PPE.
(h) The laser system should be installed in a sole use laboratory and the door kept closed during operation. The door should be labeled in accordance with ANSI Z136.1-2014.

(i) Be certain that scattered laser radiation is not escaping through a window to the outside.
(j) Label high voltage areas and investigate for other associated hazards.
(k) Eye examinations are required prior to the use of such laser systems and if an eye exposure incident should occur. Prior to ending work around lasers another eye examination is required.
(l) Warning signs will be posted in accordance with ANSI Z136.1-2014.

Section 5.04 Class 4 Lasers

Control measures for class 4 laser systems include those identified in Class 3A and 3B above in addition to the following:

(a) Goggles are required when such systems are in operation.
(b) Spectators are prohibited.
(c) The entrance to such areas must be interlocked such that entry shuts the beam down.
(d) Such systems must be in sole use areas.
(e) Access to such lasers will be controlled by keyed access to both the room and the power panel to the laser. Such key will be kept in the possession of the Principal Investigator and access will be the Principal Investigator's responsibility.
(f) Eye examinations are required prior to the use of such laser systems and if an eye exposure incident should occur. Prior to ending work around lasers another eye examination is required.
(g) The EH&S Department may institute additional control measures as deemed necessary for the safe operation of the laser.
(h) The entryway will be equipped with a lighted laser warning sign that indicates the laser is operating in accordance with ANSI Z136.1-2014.
(i) Mechanical or automated controls are implemented to along with other engineering controls to minimize or eliminate the need for class 4 exposure. Additionally, cameras shall be used when feasible for viewing class 4 lasers as a means to eliminate the need for direct exposure or persons present within the containment area.

Article VI. Alignment and Calibration

More laser accidents occur during beam alignment and system calibration than any other laser manipulation. Use the following techniques to prevent accidents.

(a) Exclude unnecessary personnel from the laser-controlled area during alignment.
(b) Perform alignment at the lowest possible power level.
(c) Use low-power visible lasers for path simulation of high-power visible or invisible lasers, when possible.
(d) Use a temporary beam attenuator over the beam aperture to reduce the level of laser radiation below the MPE, when possible.

(e) Wear laser safety eyewear during alignment. Alignment eyewear may be used when aligning a low power visible laser.
(f) Use beam display devices (image converter viewers or phosphor cards) to locate beams when aligning invisible lasers.
(g) Use shutters or beam blocks to block high-power beams at their source except when needed during the alignment procedure.
(h) Use beam blocks to block high-power beams downstream of the optics being aligned
(i) Use beam blocks or protective barriers when alignment beams could stray into areas with uninvolved personnel.
(j) Place beam blocks behind optics such as turning mirrors to terminate beams that may miss the mirrors during alignment.
(k) Locate and block all stray reflections before proceeding to the next optical component or section.
(l) Ensure that all beams and reflections are terminated before resuming high-power operation.

Article VII. Hazards

The following are hazards associated with laser activities and may be applicable in different situations.

Section 7.01 Electrical Hazards

The use of lasers or laser systems presents an electric shock hazard. Most lasers contain high-voltage power supplies and capacitors or capacitor banks that store lethal amounts of electrical energy. Exposures may occur from contact with energized components operating at potentials of 50 volts and above. During normal operations contact with energized components will be prevent by the use of insulating materials or covers. These exposures most often occur during set up or installation, maintenance, modification and service when protective covers are removed.

(a) Lasers and associated electrical equipment must be designed, constructed, installed and maintained in accordance with the latest revision of the National Electric Code (NEC.)

(b) EH&S must approve any laser equipment maintenance which involves opening protective housings or making modifications to the laser assembly unless the work is being performed by the manufacturer or qualified/licensed vendor under an existing maintenance agreement.

Section 7.02 Laser Generated Air Contaminants (LGAC)

Air contaminants may be generated when Class 4 and some Class 3b laser beams interact with matter. The quantity, composition and chemical complexity of the LGAC depend on the target material, cover gas and beam irradiance. Materials such as plastics, composites, metals and tissues may release carcinogenic, toxic and noxious air contaminants. Ozone is produced around flash lamps and can build up with high repetition rate lasers. Special optical materials used for far infrared windows and lenses may also release hazardous air contaminants.

Concentrations of LGAC must be maintained below the exposure limits specified by OSHA, NIOSH or ACGIH. There are three major control measures to reduce the concentration of LGAC to acceptable levels:

1) Use local exhaust ventilation to remove the LGAC at the point of generation. Local exhaust ventilation should be vented to the outside of the building's ceiling at a height sufficient to prevent re-entrainment to the building's air intake.
2) Isolate the process whenever possible.
3) Respiratory protection will be used only when engineering controls are not feasible EH&S must be contacted prior to wearing a respirator. Refer to the University's Respiratory Protection Program for more information. A copy of the University's Respiratory Protection Program is available on the EH&S Web Site at http://www.cpp.edu/~ehs/files/occupational/doc/RespiratoryProtection.doc.

Section 7.03 Collateral Radiation and Plasma Radiation

Collateral radiation and plasma radiation (radiation not associated with the primary laser beam) may be produced by system components such as power supplies, discharge lamps and plasma tubes. Radiation may be in the form of X-rays, UV, visible, IR, microwave and radiofrequency (RF.)

When high power pulsed laser beams (peak irradiance of 1012 W/cm2 or greater) are focused on a target, plasma is generated that may also emit collateral radiation.

Contact EH&S for evaluation of these hazards.

Section 7.04 Fire Hazards

Fire Hazards are associated with Class 4 laser beams can ignite flammable solvents, gasses and combustible materials:

To reduce fire hazards:

(a) Terminate laser beams with non-combustible materials
(b) Bring only necessary materials into the laser area.
(c) Store flammable and combustible solvents and materials properly and away from the laser beam. Use a flammable storage cabinet to store flammable materials. Solvent soaked rags must be kept in air-tight approved storage cans.

Section 7.05 Explosion Hazards

Explosion hazards and high-pressure arc lamps, filament lamps and capacitor banks may explode if they fail during operation. The laser target and elements of the optical train may shatter during operation.

(a) To reduce explosion hazards:
(b) Enclose high-pressure arc lamps and filament lamps in housings that can withstand an explosion if the lamp disintegrates.
(c) Enclose the laser target and optical train in protective housing during laser operation.
(d) Ensure that capacitors are equipped with current-limiting devices and are shielded.

Section 7.06 Compressed Gases

Compressed gases are hazardous gases are used in some laser applications including chlorine, fluorine, hydrogen chloride and hydrogen fluoride. Laboratories with compressed gases are required to have an SOP.

Section 7.07 Fluorescent Organic Compounds

Laser dyes and solvents are complex fluorescent organic compounds that are dissolved in a solvent to form a lasing medium. Some dyes are highly toxic or carcinogenic. Most solvents suitable for dye solutions are flammable and toxic by inhalation and/or skin absorption.

The following measures will be followed when working with dyes:

(a) Whenever possible, do not use dimethylsulfoxide (DMSO) as a solvent for cyanine dyes because it aids in the transport of dyes through the skin and into the blood stream. If DMSO must be used, wear gloves as recommended in the SDS. Disposable nitrile gloves may be worn if prolonged contact with DMSO is not anticipated. Other glove choices include neoprene, natural rubber and butyl gloves. PVA and PVC gloves are not recommended for use with DMSO as they are not sufficient to prevent absorption. The Chemical Hygiene Plan should be referenced for more information regarding Laboratory Safety.
(b) Obtain safety data sheets (SDSs) for all dyes and solvents prior to working with them. SDS resources are available on the EH&S website. Copies of all SDSs will be readily available to individuals in the laboratory.
(c) Prepare and handle dye solutions in a fume hood.
(d) Use disposable bench covers.
(e) Wear a lab coat, safety glasses and gloves. Contact EH&S department for assistance with glove selection.
(f) Pressure test all dye laser components before using dye solutions. Pay particular attention to tubing connections.
(g) Install spill pans under pumps and reservoirs.
(h) Consult the Chemical Hygiene Plan for more information regarding safe chemical work practices.

Section 7.08 Hearing Protection

Noise levels from some lasers, such as pulsed excimer lasers, may be high enough to require hearing protection. A good rule of thumb is if it is difficult to conduct a normal conversation at approximately 3 feet away, hearing protection may be required. Contact EH&S for noise monitoring and assistance in selecting the proper hearing protection and consult the Hearing Conservation Program for more information.

Section 7.09 Nominal Hazard Zone (NHZ)

The Nominal Hazard Zone (NHZ) is the location around the laser within which a person can be exposed to radiation in excess of the MPE. When Class 3b and 4 lasers are unenclosed, the Laser Safety Officer must establish an “NHZ”. People may be injured if they are within the perimeter of this zone while the laser is in operation.

Section 7.10 Photochemical Damage

Photochemical damage is severe at shorter visible wavelengths (violet & blue) and is cumulative over a working day.

Section 7.11 Acoustic Shock

Acoustic shock from exposure to high energy pulsed lasers may result in physical tissue damage.

Article VIII. Device Labeling

Must meet the CDRH (FDA Center for Devices and Radiologic Health) labeling standard and comply with 21 CFR 1040. The labeling must include the manufacturer's certification, identity, date of manufacture, hazard class, radiation output information and warnings, aperture dimensions, wavelength and power. Information for some of the types of Lasers used on campus is listed in the following table.

Types of Lasers Used on Campus:

Laser Type	Class	Wavelength λ	Output
Nitrogen	3b	337 nm	Pulsed
Dye	4	+/- 600 nm	Pulsed
Nd:YAG	3b	520 nm	Continuous
Helium-Neon	2, 3a, 3b	633 nm	Continuous
Semiconductor (InAlAsP)	3b	1535 nm (IR)	Continuous
Semiconductor Optical Amplifier	3a	1500-1600 nm (IR)	Continuous

Article IX. Controls

Section 9.01 Personal Protective Equipment

The PI shall provide his/her laser users with the appropriate laser protective eyewear. Laser protective eyewear must be used for beam alignments if the viewed beam exceeds the ANSI Z136.1 MPE (maximum permissible exposure) value; such activities should only be performed if automated/remote beam alignment has been fully explored and determined by EH&S to be not feasible. Intra-beam viewing of lasers is not allowed.

Exemptions from these policies may be only granted by EH&S. Some ultraviolet (UV) laser uses may require the use of skin protection. Any need for skin protection will be provided by the PI.

Selection of appropriate eyewear depends on several factors:

(a) Wavelength; eyewear must be able to attenuate or filter all wavelengths associated with the laser.
(b) Optical density; optical density at the specific wavelength must be marked on the eyewear.
(c) Luminous transmittance; luminous transmittance is the degree to which you can see through the eyewear. Most eyewear has luminous transmittance values of 10% to 70%.
(d) Damage to the eyewear; eyewear damage can occur from melting, bleaching, or shattering and therefore the eyewear should be routinely inspected.
(e) Hazards of the eyewear; some eyewear can cause dangerous reflections.
(f) Comfort and wear ability; this is one of the most important criteria when choosing eyewear. If the eyewear is not comfortable, chances are great that it will not be worn.

Section 9.02 Beam Management and Control

Beams must be restricted to the immediate location of use and must be enclosed whenever practical. Beam blocks must be used to terminate beams. The use of shutters, collimators, curtains, and other beam control devices are also strongly recommended as acceptable methods to reduce exposure or to create a controlled space. It is the responsibility of the PI to verify through survey that appropriate beam management is being practiced and to adopt acceptable controls to reduce the laser class to the lowest achievable level, practical.

Section 9.03 Posting and Labeling Requirements

All access points to the laser facility must be marked with the ANSI required standard laser hazard signs. Laser enclosures must be labeled to alert users to laser hazards as per the ANSI standard. Labels, laser hazard signs, and advice on their use are available from EH&S.

Section 9.04 Containment Area

Construct a containment area suitable to restrict access and limit exposure to the laser. The containment area should be of sufficient size to include the laser equipment, the work space and a camera system suitable for remote viewing. The containment area can be constructed using laser barriers such as screens, partitions, curtains etc. Such barriers shall be protected with an interlock system suitable to automatically de-energize the system if breached.

Section 9.05 Access Controls

Whenever the laser is in operation, access to laser facility is restricted to laser users or persons being escorted by laser users. Access control must be maintained by positive means such as locked or interlocked doors. Laser warning signs alone are not considered sufficient to control access. All persons accessing the controlled area or participating in the laser activity must sign-in and out on a user access log located in the lab, outside the containment area. The access log shall be maintained for inspection in a standard 3-ring binder for inspection. The binder shall also include the training certificates for all authorized users, Safety Data Sheets (SDS) for any chemical materials and volunteer forms for all the participants.

Section 9.06 Laser Incidents and Possible Exposures

The PI must be informed immediately of any suspected laser incidents. Should an incident occur, secure all power sources and de-energize the laser system. Verify the shut-down and that the system is secure with the two-man rule.

Following the incident, the PI is responsible for filing appropriate injury reports and to promptly initiate an investigation of all laser incidents, providing a report to EH&S.

The Accident Investigation forms for employee and students are available on the EH&S website. EH&S recommends having copies of these forms in the access log binder for ease of access and use.

(a) EH&S Website: https://www.cpp.edu/~ehs/forms.shtml

Article X. Laser Safety Training Requirements

All employees and/or individuals assigned to service, maintain, install, adjust, and operate laser equipment will be appropriately qualified and trained. The training program should be designed appropriate to the class of laser radiation accessible during the required task(s) of the personnel. Laser area supervisors, PIs and instructors shall maintain training documentation and ensure training records are completed prior to allowing users to operate the laser. Training instructions and additional references are accessible in the appendix of this manual. Training records shall be maintained for a minimum of three years.

Section 10.01 General Class Training:

limited in general, to information contained in the operation/maintenance manuals of the laser Manufacturer. Includes information contained in the operation manuals

Section 10.02 Class 2, Class 2a and Class 3a

Training includes information contained in the operation/maintenance manuals of the laser Manufacturer and, where appropriate, additional basic safety guide literature of a general topic nature. Short, concise audio-visual programs can also enhance understanding of hazards in some use scenarios especially where Class 1, Class 2a or Class 3a laser systems are subject to frequent operator changes.

Section 10.03 Class 3b and Class 4

Training is required for those working with Class 3b and Class 4 lasers, including operators, maintenance personnel, and service persons as-well-as those on the technical support staff, technicians, etc. The training should provide a complete understanding of the requirements of a safe laser environment and include discussion of the hazards, safety devices required, procedures related to operating the equipment, warning sign requirements, standard operating procedures and description of medical surveillance practices. Emphasis should be placed on practical, safe laser techniques and procedures as well as safety devices that provide an overall safe environment.

Section 10.04 Employee Training

Employees, including Faculty, Staff and Student Assistants shall complete the laser safety training web-based module through the SumTotal training portal.

Laser Safety Training

Section 10.05 Student Training

Students, graduate students, and interns must complete online laser safety training through the dedicated student training portal by utilizing the following steps:

1) Login to the student training dashboard
   Student Training Dashboard: https://ds.calstate.edu/?svc=skillsoftstudent

2) Once logged in, students can access laser safety training by searching the course library or using the following course links

i) *Injury Illness Prevention Program*
ii) *Hazard Communication*
iii) *Emergency Disaster Preparedness*
iv) *Fire Safety*
v) *Compressed Gas Safety*
vi) *Safety Data Sheets*
vii) *Laser Safety*

NOTE: CLICKING COURSE LINKS PRIOR TO ACCESSING THE STUDENT TRAINING DASHBOARD OR AFTER A SHORT PERIOD OF INACTIVITY WILL RESULT IN BEING DIRECTED TO A GENERIC CSU LOGIN PAGE WHICH WILL NOT ACCEPT YOUR BRONCO ACCESS CREDENTIALS. BE SURE TO ONLY LOGIN THROUGH THE BRANDED CPP SINGLE SIGN-ON PAGE BY USING THE LINK IN STEP 1.

Article XI. Medical Surveillance

All individuals who utilize class 3a, 3b or 4 lasers or laser systems shall have an eye examination, by an Ophthalmologist, in accordance with this section which is based on ANSI Z136.1 **Standard for the Safe Use of Lasers**. This exam shall be performed per the following schedule:

(a) Prior to the use of such laser systems;
(b) When an eye exposure incident occurs (within 48 hours); and,
(c) Prior to ending laser work

Section 11.02 Ocular History.

The past eye history and family history are reviewed. Any current complaints concerned with the eyes are noted. Inquiry should be made into the general health status with a special emphasis upon systemic diseases which might result in ocular degeneration. The current refraction prescription and the date of the most recent examination should be recorded. Certain medical conditions may cause the laser worker to be at an increased risk for chronic exposure. Use of photosensitizing medications, such as phenothiazines and psoralens increase sensitivity and overall risk factors.

Section 11.03 Visual Acuity.

Visual acuity for far and near vision should be measured with some standardized and reproducible method. Refraction corrections should be made if required for both distant and near test targets. If refractive corrections are not sufficient to change acuity to 20/20 (6/6) for distance and near vision, a more extensive examination is indicated.

Section 11.04 Macular Function.

An Amsler grid or similar pattern is used to test macular function for distortions and scotomas. The test should be administered in a fashion to minimize malingering and false negatives. If any distortions or missing portions of the grid pattern are present, the test is not normal.

Section 11.05 Color Vision.

Color vision discrimination can be documented by Ishihara or similar color vision tests.

Section 11.06 Examination of the Ocular Fundus.

Examination of the Ocular Fundus with an Ophthalmoscope or Appropriate Fundus Lens at a Slit Lamp. is a portion of the examination is to be administered to individuals whose ocular function (Ocular History, Visual Acuity, Macular Function and/or Color Vision) are not normal. The points to be covered are: the presence or absence of opacities in the media; the sharpness of outline of the optic disc; the color of the optic disc; the depth of the physiological cup, if present; the ratio of the size of the retinal veins to that of the retinal arteries, the presence or absence of a well-defined macula and the presence or absence of a foveal reflex; and any retinal pathology that can be seen with an ophthalmoscope (hyper-pigmentation, depigmentation, retinal degeneration, exudate, as well as any induced pathology associated with changes in macular function). Even small deviations from normal should be described and carefully localized. Dilation of the pupil is required.

Section 11.07 Skin Examination.

Not required for preplacement examinations of laser workers; however, it is suggested for individuals with history of photosensitivity or working with ultraviolet lasers. Any previous dermatological abnormalities and family history are reviewed. Any current complaints concerned with the skin are noted as well as the history of medication usage, particularly concentrating on those drugs which are potentially photosensitizing. Further examination should be based on the type of laser radiation, above the appropriate MPEs, present in the individual's work environment.

Section 11.08 Other Examinations.

Further examinations should be done as deemed necessary by the examiner.

Section 11.09 Records and Record Retention.

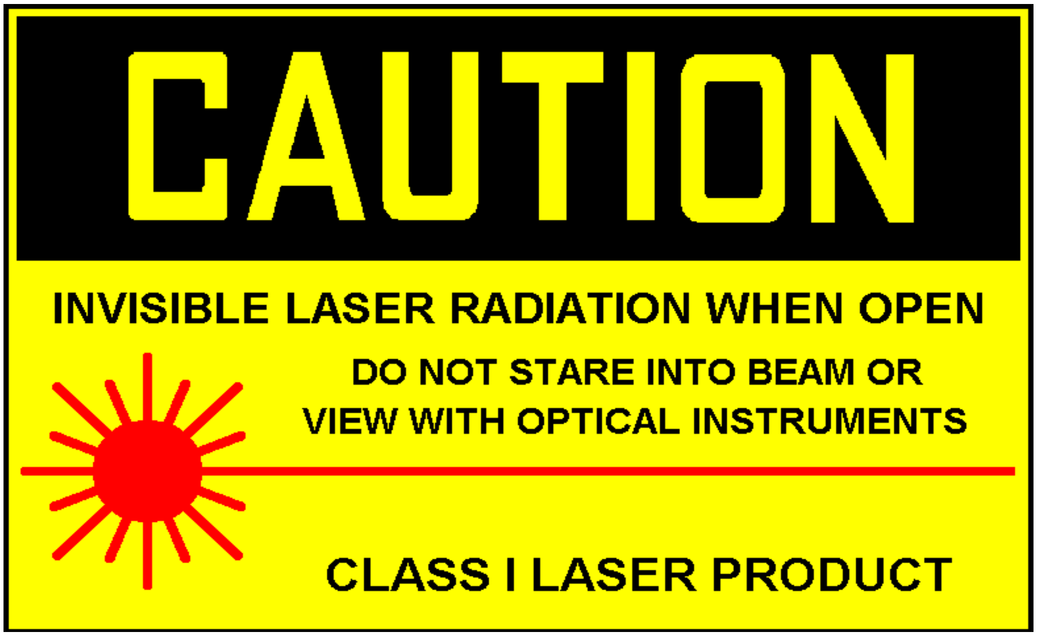
Complete and accurate records of all medical examinations (including specific test results) should be maintained for all personnel included in the University’s Environmental Health & Safety Medical Surveillance Program. Records should be retained for at least 30 years post-employment or enrollment.

Section 11.10 Access to Records.

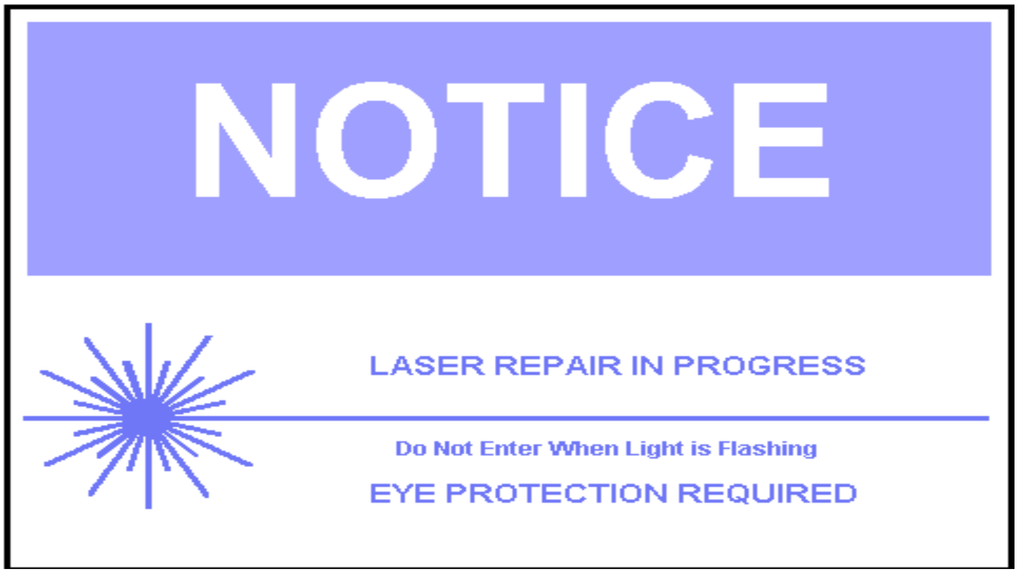
The results of medical surveillance examinations should be discussed with the employee. All non-personally identifiable records of the medical surveillance examinations should be made available on written request to authorized physicians and medical consultants for epidemiological purposes, provide such assess is approved by the patient. The record of individuals will, as is usual, be furnished upon request to their private physician, provide such assess is approved by the patient

Appendix A
Laser Safety Signs

Sample Sign for a Class I Laser



General Sample Sign for Lasers



Sample Sign for Class 3 and 4 Lasers

Notice Sign Templates for Lasers ANSI Z136.1 – 2014

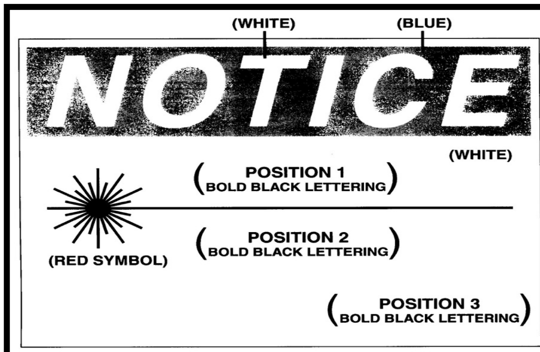


Figure 1d. Sample Warning Sign for Facility Policy, for example, Outside a Temporary Laser Controlled Area During Periods of Service

ANSI Z136.1 – 2014 Caution Sign for Lasers

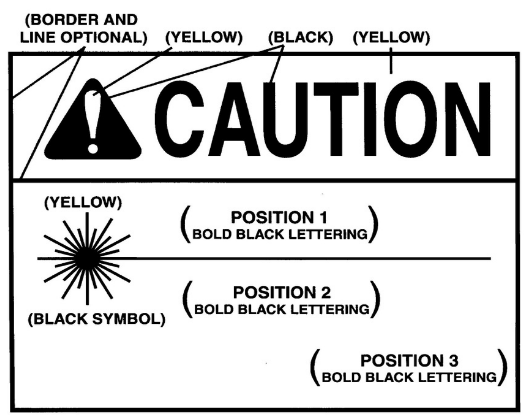


Figure 1a. Sample Warning Sign for Class 2 and Class 2M Lasers

ANSI Z136.1 – 2014 Danger Sign for Lasers

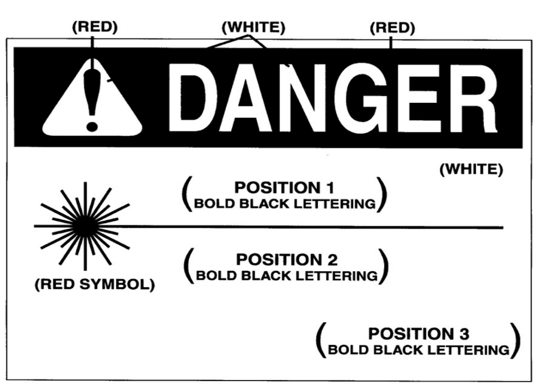


Figure 1b. Sample Warning Sign for Class 3R, Class 3B, and Class 4 Lasers

Appendix B
LASER SAFETY INSPECTION FORM

This form is a sample that can be utilized to document the Inspection of Class 3A, 3B and 4 Lasers or Laser Systems.

Part 1: Identification

Date of Inspection:		*Location:*	
PI/Laboratory Supervisor:		*Department:*	
Laser Type:	*Class:*	*Model:*	*Serial Number:*

Part 2: Documentation

	Yes	*No*	*N/A*	*Corrective Actions/Comments*
The Laser is registered with EH&S				
Standard Operating Procedures (SOP) are posted				
Alignment procedures are posted				
Interlock test procedures are posted				
List of authorized users are posted				
Records of training/medical surveillance (if applicable)				
Eyewear inventory and inspection records are available and maintained				
Other relevant documentation				

Part 2: Engineering Controls

	Yes	*No*	*N/A*	*Corrective Actions/Comments*
Protective housing				
Alternative controls if housing open/removed				
Interlock on housing functional (test or check test records)				
Viewing windows/optics do not allow exposure >MPE				
Beam shutter functional				
Key control functional, key security adequate				
Laser activation warning system functional (visible or audible)				
Remote interlock connector functional (used or not)				
Laser labels (class, aperture, access, etc.) present				
Labels on long (>3m) conduits present				

Controlled operation for class 4 lasers (remote control and monitoring)				
Modified/home build lasers classified				
Beam enclosure adequate				
Beam enclosure labeled				
Beam Path is:				
-Enclosed				
-Limited				
-Open				

Part 3: Laser Control Area

	Yes	*No*	*N/A*	*Corrective Actions/Comments*
Access controlled to permit only trained personnel				
Entrance posted with warning signs, outside/inside				
OD and wavelength of required eyewear posted on sign				
Beam path is well defined:				
-laser secured to optical table or other fixture				
-optical components in beam path secured				
-possible stray beams eliminated				
-beam barriers, stops, shrouds, curtains adequate				
Beam properly terminated				
Windows/doorways/open portals covered				
Area supervised by individual trained in laser safety				
Area located so that access by spectators is limited				
Only diffuse reflecting materials in or near beam path				
Adequate eye protection provided to all personnel				
Exposed beam not at eye level in any standing or seated position				
Laser disabled when not in use (e.g. key removed)				
Emergency stop functional				
Entryway controls:				
-permit rapid exit at all times and access in emergency				
personnel requiring entry are:				
-trained				
-provided with PE				
-able to follow administrative and procedural controls				

Non-defeatable interlock/Interlock functional				
Defeatable interlock/interlock functional				
Procedural entryway controls:				
-authorized personnel adequately trained (laser and safety), and PPE provided upon entry				
-a door, blocking barrier, curtain, etc. present at entryway				
-laser status indicator outside room functional				

Part 4: Administrative & Procedural Controls

	Yes	*No*	*N/A*	*Corrective Actions/Comments*
Standard Operating Procedures (SOPS)				
Output Emission Limitations (LSO discretion)				
Personnel have been trained (records)				
Laser is operated by authorized personnel (list, records)				
Alignment procedures				
Appropriate procedures for spectators implemented				
Service personnel adequately trained				

Part 5: Protective Equipment

	Yes	*No*	*N/A*	*Corrective Actions/Comments*
Required eye protection is available				
Eyewear labeled with OD and wavelength(s)				
OD and wavelength are adequate for laser(s) in use				
Physical condition/Inspection records				
Required skin protection available				

Part 6: Non-Beam Hazards

	Yes	*No*	*N/A*	*Corrective Actions/Comments*
Electrical (HV) shock hazard				
Spark ignition of flammable materials				
Other electrical hazards				
Collateral or plasma radiation				
Fire/explosion hazard				
Noise hazard				
Laser Generated Air Contaminants (LGAC)				

Compressed gases				
Gas cylinders properly restrained				
Toxic laser dyes or solvents				
Hazardous materials storage and handling				
Proper disposal of chemical waste				
Fume hood for dye mixing				
Cryogenics				

Part 7: Other Observations/Comments

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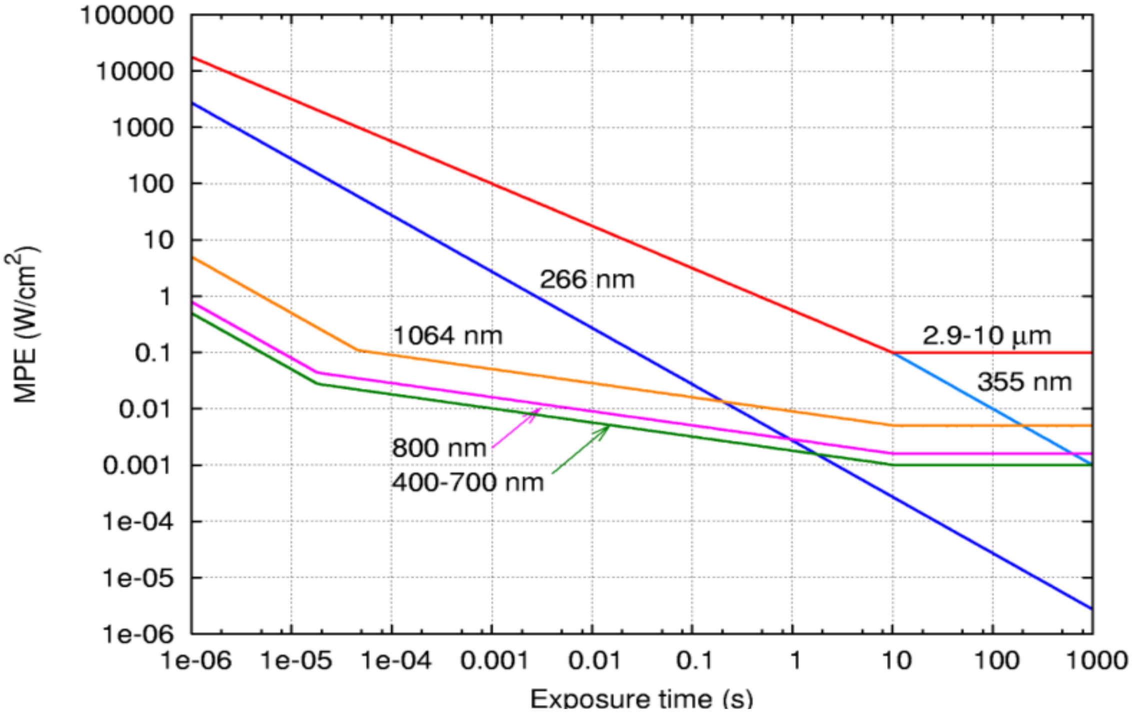
____
____
____

Revised: 05/11/2009

Appendix C
MPE as Power Density versus Exposure Time for Various Wavelengths:



Appendix D
Hazards of Various Laser Wavelengths

Electromagnetic Spectrum Region	Wavelength Range λ	Organ Affected	Effect
Ultraviolet	200 to 400 nm	Cornea, Lens, Skin	
UV-C	200 to 280 nm	All absorbed in Cornea and Conjunctiva	Photokeratitis
UV-B	280 to 315 nm	Almost all absorbed in Cornea- Conjunctiva Cataract formation	Photokeratitis
UV-A	315 to 400nm	All absorbed in lens. Cataract formation.	Cataract
VISIBLE LIGHT	400 to 780 nm	Retina	Retinal Injury
NEAR INFRARED	780 nm to 1.4um	Retina, Lens, Skin	
MID AND FAR IR			
IR-B	1.4 -3.0 um	Cornea and Skin	Retinal burn, cataract
IR-C	3.0 um to 1 mm	Cornea and Skin	Corneal burn

EH&S Office Use Only

California State Polytechnic University, Pomona
Office of Environmental Health and Safety

Laser Registration Form

Employee Name:________________________________ Bronco ID:_________________

Department:____________________________________ Extension:__________

Equipment Overview:

Serial No:_________________________ Model No.________ Max Power (W):__________

Wavelength:________ Type:________ Class:________ Output:_____________

Compressed Gases:________________ Location:____________ Medium:____________

Purpose of Laser Operations:____

____

____

CERTIFICATIONS

___________________________________ ____________________
Principle Investigator *Date*

___________________________________ ____________________
Department Chair *Date*

___________________________________ ____________________
Environmental Health and Safety Manager *Date*

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