Tufts University Laser Safety

Policy and Procedures Manual

TUFTS ENVIRONMENTAL HEALTH AND SAFETY
July 2014

PUBLIC AND ENVIRONMENTAL SAFETY
Environmental Health and Safety

The policy and procedures manual was developed for researchers at Tufts University (TU) and is designed to protect employees, students and visitors, and ensure compliance in environments that either store or use lasers or laser systems. Laser personnel are obligated to fully understand and comply with all TU safety policies documented in this manual, in addition to, pertinent regulatory requirements as promulgated by state, federal, and local agencies. This manual will continue to be developed through the guidance and support from both Tufts Environmental Health and Safety (TEHS) and the Tufts Radiation Safety Committee.

Sincerely,

Geoffrey C. Sirr Jr., Radiation Safety Officer

Geoffrey C. Sirr Jr. **2/25/16**

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1. Policy

1.1. All personnel required to work in a Laser Work Environment should review the Tufts University Laser Safety Policies and Procedures Manual and participate in accordance with Massachusetts Department of Public Health Radiation Control Program 105 CMR 121.000, Laser System[1], and the American National Standard Institute (ANSI) Standard for the *Safe Use of Lasers*, ANSI Z136.1[2] (copy on file with the Environmental Health & Safety Office, 419 Boston Ave).

1.2. To prevent inadvertent exposures involving any laser source or sources of radiation to personnel.

1.3. To limit laser applications to research or medicinal purposes and avoid deliberate acts that impact safety.

2. Purpose

2.1. To administer the Tufts University policies and procedures, through comprehensive programs for developing safety techniques and laser safety awareness.

2.2. To recognize potentially significant sources of laser radiation and minimize hazards to as low as reasonably achievable (ALARA) conditions.

2.3. To ensure effective laser safety controls are developed and utilized.

2.4. To ensure qualified laser safety personnel and adequate protection for workers.

2.5. To demonstrate compliance with regulations.

3. Scope

3.1. Does not address ionizing radiation emitted by radioactive materials or machines.

3.2. Applicable to research and clinical application on the Boston, Grafton and Medford Campus.

3.3. Applicable to all personnel working at or visiting Tufts University whom procure, dispose or operate Class IIIB and Class IV laser systems.

3.4. Does not apply to Class I and Class II laser equipment, unless servicing or modification to each system causes unsafe conditions or manufacturer classification is no longer valid due to a change in design or accessible emission limits.

3.5. The manual is based upon best practices at Tufts University, standards and regulations published by the American National Standards Institute (ANSI) and The Commonwealth of Massachusetts Department of Public Health 105 CMR 121.000 respectively.

4. Definitions

4.1. **aversion response:** Movement of the eyelid or the head to avoid an exposure to a noxious stimulant or bright light. It can occur within 0.25 s, including the blink reflex time.

4.2. **collimated beam:** Effectively, a "parallel" beam of light with very low divergence or convergence.

4.3. **continuous wave (cw):** The output of a laser which is operated in a continuous rather than a pulsed mode. In this standard, a laser operating with a continuous output for a period ≥0.25 s is regarded as a cw laser.

4.4. **diffuse reflection:** Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

4.5. **divergence:** The increase in the diameter of the laser beam with propagation distance from the exit aperture. Sometimes this is also referred to as beam spread.

4.6. **embedded laser:** A laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the system’s lower classification is the result of engineering features which limits the accessible emission.

4.7. **energy:** The capacity for doing work. Energy content is commonly used to characterize the output from pulsed lasers, and is generally expressed in joules (J).

4.8. **failsafe interlock:** An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

4.9. **fire retardant:** A material which does not support combustion without an external source of heat such as a laser.

4.10. **hertz (Hz):** The unit which expresses the frequency of a periodic oscillation in cycles per second.

4.11. **infrared radiation:** Electromagnetic radiation with wavelengths which lie within the range 700nm to 1mm.

4.12. **intrabeam viewing:** The viewing condition whereby the eye is exposed to all or part of a laser beam.

4.13. **ionizing radiation:** Electromagnetic radiation having a sufficiently large photon energy too directly ionize atomic or molecular systems with a single quantum event.

4.14. **irradiance (at a point of a surface):** Quotient of the radiant flux incident on an element of the surface containing the point at which irradiance is measured, by the area of that element, expressed in units of watts per square centimeter (W/cm^2).

4.15. **Joule:** A unit of energy. joule = watt x second.

4.16. **laser:** A device which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.

4.17. **laser controlled area:** An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from radiation hazards.

4.18. **laser safety officer (LSO):** A person appointed by the administration to administer a laser safety program. The person is responsible for effecting the knowledgeable evaluation of laser hazards, and is authorized and is responsible for monitoring and overseeing the control of such laser hazards.

4.19. **laser system:** An assembly of electrical, mechanical, and optical components which includes a laser.

4.20. **limiting aperture: T**he maximum diameter of a circle over which irradiance and radiant exposure can be averaged.

4.21. **limiting exposure duration:** An exposure duration which is specifically limited by the design or intended use(s).

4.22. **maximum permissible exposure (MPE):** The level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the eye or skin. The criteria for MPE for the eye and skin are detailed in ANSI Z136.1, Section 8.

4.23. **nominal hazard zone (NHZ):** The space within which the level of the direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

4.24. **nominal ocular hazard distance (NOHD):** The distance along the axis of the unobstructed beam from the laser to the human eye beyond which the irradiance or radiant exposure during normal operation is not expected to exceed the appropriate MPE.

4.25. **optical density (D_λ)** Logarithm to the base ten of the reciprocal of the transmittance: $D_\lambda = -\log_{10} \iota_\lambda$ where ι is transmittance at the wavelength λ.

4.26. **plume:** Aerosol created by vaporization of tissue or metals that may contain viable bacteria, virus, cellular debris, or noxious and possibly toxic metallic fumes.

4.27. **power:** The rate at which energy is emitted, transferred, or received, in units of watts (joules per second).

4.28. **prf:** Abbreviation for pulse-repetition frequency. See *repetitively pulsed laser.*

4.29. **protective housing:** An enclosure that surrounds a laser or laser system that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing may enclose associated optics and a workstation and shall limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals.

4.30. **pulse duration:** The duration of a laser pulse; usually measured as the time interval between the half-power points on the leading and trailing edges of the pulse.

4.31. **pulsed laser:** A laser which delivers its energy in the form of a single pulse or a train of pulses. In this standard, the duration of a pulse <0.25 s.

4.32. **radian (rad):** A unit of angular measure equal to the angle subtended at the center of a circle by an arc whose length is equal to the radius of the circle. 1 radian ≅57.3 degrees; 2π radians = 360 degrees.

4.33. **radiance:** Radiant flux or power output per unit solid angle per unit area in units of watts per centimeter squared per steradian (W/cm^2 sr).

4.34. **radiant energy:** Energy emitted, transferred, or received in the form of radiation in units of joules (J).

4.35. **radiant exposure:** Surface density of the radiant energy received in units of joules per centimeter squared (J/cm^2).

4.36. **radiant flux:** Power emitted, transferred, or received in the form of radiation in units of watts (W). Also called *radiant power.*

4.37. **radiant intensity (of a source in a given direction):** Quotient of the radiant flux leaving a source and propagated in an element of solid angle containing the given direction, by the element of solid angle in units of watts per steradian (W/sr).

4.38. **radiant power:** See *radiant flux.*

4.39. **reflectance:** The ratio of total reflected radiant power to total incident power. Also called reflectivity.

4.40. **repetitively pulsed laser:** A laser with multiple pulses of radiant energy occurring in sequence with a prf≥1 Hz.

4.41. **shall:** The word "shall" is to be understood as mandatory.

4.42. **should:** The word "should" is to be understood as advisory.

4.43. **specular reflection:** A mirror reflection.

4.44. **transmission:** Passage of radiation through a medium.

4.45. **transmittance:** The ratio of total transmitted radiant power to total incident radiant power.

4.46. **ultraviolet radiation:** Electromagnetic radiation with wavelengths smaller than those of visible radiation; for the purpose of this standard, 180 to 400 nm.

4.47. **visible radiation (light):** Electromagnetic radiation which can be detected by the human eye. This term is commonly used to describe wavelengths which lie in the range 400 to 700 nm.

4.48. **watt (W):** The unit of power or radiant flux. watt = joule per second.

4.49. **Wavelength:** The distance between two successive points on a periodic wave which have the same phase.

5. Administration, Delegation of Authority and Laser Safety Officer

5.1. The President of Tufts University delegates authority in matters pertaining to the University Radiation Safety Program to the Office of the Vice Provost. The Office of the Vice Provost:

5.1.1. Assumes overall responsibility for the Laser Safety Program (LSP) through the designated Laser Safety Officer (LSO).

5.1.2. Participates jointly with LSO to establish LSP policies that provide adequate radiation protection and continue to meet regulatory requirements.

5.1.3. Supports the development and continuing review of the LSP to ensure that radiation protection requirements are met.

5.1.4. Ensures the implementation of appropriate controls based upon the recommendations of the LSO.

5.2. The LSO has the authority to manage the Laser Safety Program, identify laser safety hazards, initiate, recommend or provide corrective actions and ensure compliance with regulations for the safe use of laser systems. The LSO acts as liaison with regulators, oversees all radiation safety aspects of the LSP, has the authority to immediately stop any operation involving the use of lasers in which health or safety may be compromised or which may result in non-compliance with the applicable regulations.

The following list summarizes the primary objectives and responsibilities of the LSO:

- To support the development of laser safety policies and procedures.
- To review and approve laser safety permits.
- To advise management on laser safety requirements and regulatory updates.
- To review deficiencies and incidents and assess what corrective actions if any are required.

6. Principal Investigator (PI)

6.1. Principal Investigator Appointment Process

Individual full-time University employees with the following appointment titles are eligible to serve as a PI:

- Professor, Research Professor, or Clinical Professor
- Associate Professor, Research Associate Professor, or Clinical Associate Professor
- Assistant Professor, Research Assistant Professor, or Clinical Assistant Professor

Individuals appointed with titles such as Research Associate, Postdoctoral Fellow or Graduate student are not eligible to serve as a PI unless the sponsor award is specifically directed at such individuals (such as a fellowship application) and appropriate faculty supervision is assured, by a member of Tufts Faculty who is eligible to serve as a PI.
Other individuals may serve as a PI, but only on an **exceptional** basis. Approval may be granted by personnel from the Office of Research Administration upon the written recommendation of the appropriate Academic Departmental Chair and with the signed concurrence from the appropriate Dean.

7. Responsibilities

7.1. Laser Safety Officer: The LSO is responsible for administering the Laser Safety Program (LSP), maintaining a list of laser permitted PI's and assigned Laser Safety Liaison, and maintaining a database of all registered Class 3b & 4 lasers and relevant LSP records.

7.2. Principal Investigators (PI): Each permitted PI will be responsible for ensuring that all activities in their laboratory or other permitted area and involving laser systems are in compliance with Tufts University policy and the applicable regulations. PI's are responsible for all laser use in their assigned areas including laser equipment registration, safety procedures and training of employees, contractors and visitors.

PI's are also responsible for the following:

7.2.1. Registration of Class 3b and Class 4 laser systems with TEHS.

7.2.2. Scheduling laser safety inspection for newly designed laser laboratory.

7.2.3. Ensuring adequate training is provided to individuals assigned to work in a laser laboratory environment.

7.2.4. Providing the necessary equipment and work environment for the safe use of the project's lasers.
7.2.5. Providing adequate protective equipment to personnel (i.e. eyewear, laboratory coats, etc.).
7.2.6. Providing accurate laser system inventory to Radiation Safety staff for registration purposes.
7.2.7. Notifying Radiation Safety staff of any personnel changes to existing permits.
7.2.8. Establishing appropriate procedures to ensure that laser systems are properly managed, stored and controlled.

7.3. Laser Workers are responsible for the following:

7.3.1. Complying with all requirements of the Tufts University Laser Safety Policies and Procedures Manual.
7.3.2. Registering with TEHS.
7.3.3. Wearing appropriate personal protective equipment (i.e. laser eyewear and laboratory coats)
7.3.4. Conducting all laser activities in accordance with laboratory standard operating procedures.
7.3.5. Participation in departmental laser safety training.
7.3.6. Completion of the “Introduction to Laser Safety” training prior to entering a laser controlled area.
7.3.7. Operation of Class 3B or Class 4 lasers with authorization from the laser safety supervisor.
7.3.8. Notification of laser incidents to the LSO and/or the laser safety supervisor.
7.3.9. Reports any equipment malfunction or potential hazard to the laser safety supervisor.

7.4. Departments: Each department which uses Class 3b or Class 4 lasers is responsible for appointing a person to function as the Laser Safety Liaison. This person will coordinate the use of lasers by the department with the services provided by TEHS.

7.5. Laser Safety Liaison’s are responsible for the following:

7.5.1. Maintaining a list of laser workers with the department and TEHS
7.5.2. Informing TEHS of new laser installations or major changes in a permitted laser laboratory.
7.5.3. Assisting the Department Supervisor / PI in his/her responsibilities to ensure compliance.

8. Laser Facility Registration

8.1. The Department of Public Health (DPH) - Radiation Control Program requires each person who owns or possesses and administratively controls a laser facility to apply for registration prior to the operation of a laser facility. Tufts University is registered with the DPH as a laser facility, and continues to administratively support and control all campus locations that utilize one or more class 3B and 4 lasers or laser systems.

8.2. In addition to the requirements of registration, all registrants are subject to the applicable provisions of other parts of 105 CMR 121.000 (regulatory document is available by visiting the following website http://www.mass.gov/eohhs/docs/dph/regs/105cmr121.pdf or contacting TEHS).

9. Laser Permit

9.1. Each PI requesting to use Class 3B or 4 lasers in a laboratory under their jurisdiction is required to complete and forward form LSP-001 (Appendix A) to the LSO. Each permit details general information, equipment inventory, laser parameters, areas of use, trained personnel, and additional information related to laser research application. Permits are signed by the PI and departmental chairperson, and reviewed by the LSO. Applications completed and submitted by PI's are either approved by the LSO as written, or returned for additional information or edit. Those permits approved by the LSO are assigned a unique permit number and filed within TEHS. Copies of signed permits are provided to PI's for their record and future reference. Each approved permit is valid for a period of five years.

The permit application is available by visiting the Tufts EHS website: http://publicsafety.tufts.edu/ehs/files/ehsLSP-001.pdf;. Both electronic and signed originals should be forwarded to the LSO upon completion.

Registration Criteria Summary:

- Existing Class 3b and 4 laser and laser systems
- Alterations or modifications that change current classification
- Permanent or temporary acquisition of Class 3b and 4 laser and laser systems
- Purchase of Class 3b and 4 laser and laser systems

9.2. Amendments to and Renewal of Laser Permit

Permits are issued for a 5 year period and expire thereafter unless renewed. It is the responsibility of PI's to conduct a timely renewal of their respective permit within 30 days prior to expiration. PI's may renew by submitting an electronic copy of LSP-001 to the LSO.

Amendments are used to correct errors, request changes, or change information pertinent to the laser permit. All amendments, regardless of its magnitude, must]be requested in writing.

10. Laser System Disposal, Securing or Transfer

10.1. Researchers are required to contact the Laser Safety Officer (LSO) via phone at (617)636-3450 or email: Geoff.sirr@tufts.edu., prior to transferring lasers from or on Tufts University (TU) property. Regulation requires that TU maintain records of receipt, transfer or disposal of a laser system with class 3B or 4 ANSI classifications.

10.2. Often most electronic devices rendered as waste contain some quantity of hazardous material (i.e. plasma tubes or ceramics containing beryllium oxide, diodes containing gallium arsenide or lead etched circuit boards) and are subject to regulatory disposal requirements.

10.3. The following options and suggestions are provided for those considering disposal of a laser system.

10.3.1. Review the laser system manual for warning or caution statements that list hazardous materials and or recommendations for disposal of hazardous materials.

10.3.2. Contact the manufacturer technical support group for assistance in determining the hazardous materials contained within the laser system.

10.3.3. Ask for manufacturer recommendations for disposal or recycling.

10.3.4. Inquire if a ”take back” program exists. Often manufacturers offer this service to assist customers, recycle materials for future manufacturing or refurbishment.

10.3.5. Contact TEHS for further guidance.

10.4. Disposal

10.4.1. Disposal is an option when lasers are of no value and after the laser is inactivated / de-energized.

10.4.2. TEHS staff participates or assists in the identification, removal and segregation of hazardous materials. Hazardous materials (oils, dyes etc.) are then managed as waste in accordance with the applicable regulations.

10.4.3. Decontamination Clearance: Complete TEHS “Equipment Hazard Clearance Tag” (Radiological, Biological, Chemical and Other (freon, lead, electrical).

10.5. Securing / Tagging equipment for disposal

10.5.1. Researchers are responsible for their laser system equipment during the disposal process and are expected to continue to oversee the control of equipment within their respective research environment to ensure safety.

10.5.2. Lasers tagged for disposal must be made inoperative to protect others from injury.

10.5.3. Disable the laser equipment to avoid an injury to others.

10.5.3.1. Remove and secure key and power cords

10.5.3.2. Separate and secure external hardware that energizes the laser

10.5.3.3. Final inactivation may involve discharging electronic elements; in some cases, it may be necessary to have an engineer or specialist perform this service.

10.5.4. TEHS provides equipment tags. Contact TEHS at 6-3615 to request a tag and initiate the equipment clearance process.

10.6. Transfer

10.6.1. Transfers can be made only if the system is in good working order, with all safety systems intact.

10.6.2. Internal transfers require review and approval by the LSO prior to transfer.

10.6.3. External transfers require that the recipient be an entity that is qualified to safely operate the laser system, that the system be fully inspected before transfer and that Tufts be fully released from liability by the recipient. Release forms are provided by TEHS as needed.

11. Laser Safety Training

11.1. The introductory training is required for all members entering a laser work environment. The training will focus on Laser Safety and the topics include:

- Learn the fundamentals and terminology necessary for a complete understanding of current laser safety information.
- How to determine Nominal Hazard Zones (NHZ), Maximum Permissible Emission Level (MPE), or Optical Density.
- Review control measures and personal protective equipment.

- Non-ionizing regulations that apply.
- Introductory to laser effects on the bodily tissue.
- Non-beam issues such as laser-generated airborne contaminants and electrical hazards.
- Review Tufts administrative controls (permitting equipment, inventory registration, etc.)

11.2. TEHS offers training on all campuses throughout the year as a service to the Tufts University community. Class size is limited and certificates of attendance will be provided at the end of each session; **Registration is required**. Please contact TEHS (ehs-training@tufts.edu) to reserve your spot.

12. Medical Surveillance

12.1. Tufts University Faculty, staff, and students working with class 3B or 4 lasers are strongly encouraged to participate in the baseline eye examination assessment. The eye exam establishes a baseline against which ocular damage may be measured. Medical examinations are required for a suspected or actual laser induced injury. Personnel are required to report to their supervisor immediately and Occupational Health Services within 48 hours or as soon as possible for post injury assessment.

12.2. Promptly refer individuals:

- Requesting a baseline eye examination to an ophthalmologist
- That have a known or suspected eye injury to an ophthalmologist
- That have skin injuries to a physician

12.3. Personnel seeking occupational health services are advised to contact Occupational Safety Services directly or follow the Baseline Medical Surveillance Procedure. Employee health related services are provided on all three campus locations. The baseline eye examinations are performed at the **Mount Auburn Hospital**, Occupational Health Services**,** located at 725 Concord Avenue, Suite 5100, Cambridge, MA 02138. The following information is provided for your assistance in arranging for an eye exam. Each department or laboratory is responsible for all fees and costs associated with the baseline or post injury eye exam. This fee is currently $62 per person and employees will not need to pay anything at the time of the visit; TEHS will pay for the initial visit and will bill the departments separately.

12.4. Baseline Medical Surveillance Procedure

12.4.1. Contact Mount Auburn Hospital by dialing **617-354-0546** to schedule the examination.

12.4.2. Inform the representative that:

12.4.2.1. You are from Tufts University and are part of the "***Tufts Laser Vision Environmental Group***"

12.4.2.2. You work in a laser laboratory and a baseline eye examination is recommended.

12.4.2.3. You will need a copy of your examination results for the purpose of your own record.

12.4.3. Anticipate a temporary impaired vision after the examination.

12.4.4. If you need further information or have any questions, please contact TEHS at 617-636-3615.

13. Emergency Support

13.1. For emergencies Contact Tufts Police:

13.1.1. Boston Campus Emergency
(617) 636-6911 or x66911

13.1.2. Grafton Campus Emergency
(508) 839-5303 or x66911

13.1.3. Medford/Somerville Campus Emergency
(617) 627-6911 or x66911

13.2. Tufts Police will provide transport services to the nearest hospital.

13.3. Report all actual or suspected laser eye injuries to TEHS (617-636-3615) as soon as possible. Personnel with actual or suspected laser eye injuries must have a medical eye exam, preferably within 48 hours.

13.4. File a laser incident report with TEHS.

13.5. The LSO will investigate any reported exposure to laser radiation and file a report, and maintain a copy in the laser workers' registration file.

14. Laser Safety Introduction

The acronym **LASER** stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. A laser is a device, which when energized, can emit a highly collimated beam of extremely intense monochromatic light. The non-ionizing (i.e for the purpose of research applications) radiation is emitted over a wide range of the electromagnetic spectrum, starting in the ultraviolet region (100-400 nm) through the visible (400-700 nm) and near infrared &infrared region combined (>700-10,600 nm). Lasers are designed to function in a continuous or pulsed mode.

The safe use of laser systems depends upon the basic principles of safety, which are recognition, evaluation, and control of potential hazards. This program will review laser operations, the associated potential hazards, responsibilities of the laser user community, and the services provided by the LSO to help in the safe use of laser radiation.

15. Laser Radiation Effects on Tissue

15.1. Biological effects associated with laser use are dependent on laser type & wavelength, operating parameters, mode of use and the environment in which it is used.

Factors influencing tissue interaction:

- Spot size
- Wavelength
- Energy or power delivered
- Duration of application
- Mode of energy delivery
- Type of tissue (transparent, weak scattering, or strong scattering)

Strong scattering biological tissues and fluids include: blood, lymph, skin, brain, vessel walls, eye sclera, are opaque to wavelengths shorter than 300 nm (ultraviolet). Weak scattering (transparent) tissues and fluids include: the cornea, crystalline lens, and aqueous humor of the front chamber of eye. Other factors that affect energy absorption are tissue pigmentation and water content.

15.2. Specific Laser Tissue Interaction

15.2.1. Thermal Damage - occurs when the temperature of the tissue exceeds a critical threshold, resulting in denatured proteins or carbonization of the tissue.

15.2.2. Photocoagulation: involves denaturing of proteins. Blood is coagulated and inflammation is produced which serves to create desired scarring and adhesions. During this process the laser is focused on pigmented tissue to be treated. The energy is absorbed and the tissue increases in temperature. Photocoagulation occurs when tissue is warmed by 10-20 degrees centigrade.

15.2.3. Photovaporization: is dependent upon light absorption by pigment Higher-powered laser delivered in brief bursts with local temperature rises to 60-100 degrees centigrade. This reduces tissue to CO_2 and H_2O and vapor is created.

15.2.4. Photochemical: mainly occurs for exposure to continuous wave lasers or repeated exposures to irradiance levels which are too small to cause an increase in thermal temperature. Photochemical damage occurrence is low in the ultraviolet and blue end of the visible spectrum, peaking at about 440 nm.

15.2.5. Thermomechanical: damage results from acoustic shock waves generated by very short pulses, “non-linear effects” occur, such as photodisruption and photoablation.

15.2.6. Photodisruption: involves the delivery of large amount of energy over a small focal spots in a short time interval (nanoseconds to picoseconds). This mechanism is non-pigment dependent, non-thermal and occurs in the infrared spectrum. The heating is instantaneous with minimal outward dissipation.

15.2.7. Photoablation: decomposition occurs for short pulse high irradiance exposure at the molecular level and involves the cleavage of molecular bonds (a photochemical process). The effects involve rupture of tissue due to shockwave and the process is non-pigment dependent and non-thermal.

As a general rule, ultraviolet (UV) wavelengths and far-infrared wavelengths are not very penetrating. Visible light and near-infrared band penetrate tissue to varying degrees. Wavelengths below 300 nm are not considered to be deep penetrating and in fact only are absorbed superficially. Near–infrared (IR-A) is the most penetrating in all tissues; a common laser used in the OR today is the ND:YAG(1064nm). Since tissue is neither non-uniform nor homogeneous, tissue interaction does not follow an exponential absorption. Those wavelengths that penetrate to greater depths in tissue are selective for a specific surgical effect.

The primary biological effects when working with laser systems are photocoagulation and thermal ablation (vaporization). Each mechanism depends on irradiation spot size, exposure time and optical penetration depth. Photochemical reactions are of lesser interest in laser surgical applications. Shorter wavelength lasers (ultraviolet and short visible) are capable of initiating photochemical reactions.

Corneal or retinal burns are possible from acute exposure. The location and extent of injury is dependent upon wavelength and classification of laser.

Corneal opacities (cataracts) or retinal injury may be possible from chronic, as well as acute, exposures to excessive levels of laser radiation. Eye hazards are easily controlled with the use of appropriate laser safety eyewear, or other engineering safety controls.

Skin burns are possible from acute exposure to high levels of laser radiation in the infrared spectral region. Erythema (sunburn), skin cancer, and accelerated skin aging are possible effects in the ultraviolet wavelength range. Laser light, especially ultraviolet wavelengths, may stimulate cellular responses that persist even after the tissues are no longer exposed (photochemical).

16. Exposure to the Eye and Skin

Laser irradiation of the eye may cause damage to the cornea, the lens, or the retina, depending on the wavelength of the light and the energy absorption characteristics of the ocular media (see Fig.1). Lasers cause biological damage by depositing heat energy in a small area, or by photochemical processes. Infrared, ultraviolet, and visible laser radiation are capable of causing damage to the eye.

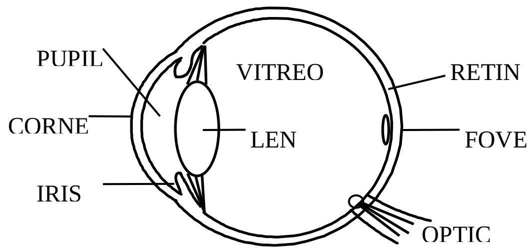


Figure 1, Schematic Diagram of the Human Eye

16.1. **Retinal Damage**
Visible and Infrared A (Spectral Regions 400-760 nm and 760-1400 nm)

Visible and Infrared A wavelengths penetrate through the cornea to be focused on a small area of the retina, the fovea centralis (see Fig. 2). This process greatly amplifies the energy density and increases the potential for damage. Lesions may form on the retina as a result of local heating of the retina subsequent to absorption of the light.

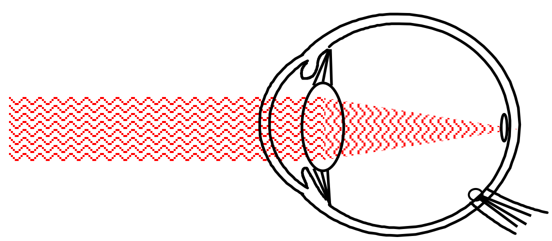


Figure 2, Ocular Absorption of Visible Light and Infrared A

16.2. Lens Damage

Ultraviolet A (Spectral Region 315-400 nm)

Wavelengths in this spectral region are primarily absorbed in the lens (see Fig. 3). Damage to this structure, either photochemical or thermal, disrupts the precise relationship between the tissue layers of the lens. This results in areas of increased light scatter - a cataract. Under normal conditions, the lens will begin to harden with age. Exposure to UV-A accelerates this process and may lead to presbyopia (the loss of the ability of the lens to accommodate or focus).

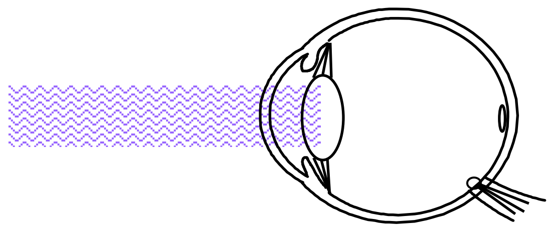


Figure 3, Ocular Absorption of Ultraviolet A

16.3. Corneal Damage

Infrared B and Infrared C (Spectral Region 1.4 to 100 µm)

The cornea of the eye is opaque to infrared radiation (see Fig. 4). The energy in the beam is absorbed on the surface of the eye and damage results from heating of the cornea. Excessive infrared exposure causes a loss of transparency or produces a surface irregularity on the cornea.

Ultraviolet B and Ultraviolet C (Spectral Region 100-315 nm)

The cornea of the eye is also opaque to ultraviolet radiation. As with infrared radiation, the energy of the beam is absorbed on the surface of the eye and corneal damage results (see Fig. 4). Excessive ultraviolet exposure results in photokeratitis (Welder's Flash), photophobia, redness, tearing, conjunctival discharge, and stromal haze. There is a 6-12 hour latency period before symptoms to photochemical damage appear.

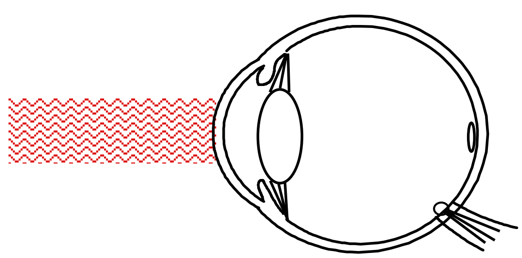


Figure 4, Ocular Absorption of Infrared B, Infrared C, Ultraviolet B and Ultraviolet C

16.4. Other Ocular Damage

There are two transition zones between corneal hazard and retinal hazard spectral regions. These are located at the bands separating UV-A and visible, and IR-A and IR-B regions. In these regions, there may be both corneal and retinal damage. An example of this hazard would be the Nd:YAG near-infrared region laser. This wavelength can be focused by the eye but not perceived by it. Damage can thus be done to the retina in the same manner as visible light even though the beam itself remains invisible.

16.5. Skin Exposure

Acute exposure of the skin to large amounts of energy from the laser may cause burning of the skin. These burns are similar to thermal or radiant (sun) burns. The incident radiation is converted to heat that is not dissipated rapidly enough due to poor thermal conductivity of the tissue. The resulting local temperature rise causes denaturation of tissue protein. Injury of the skin depends on the wavelength of laser light, exposure time, and degree of skin pigmentation. Skin carcinogenesis may occur at some specific ultraviolet wavelengths (290-320 nm).

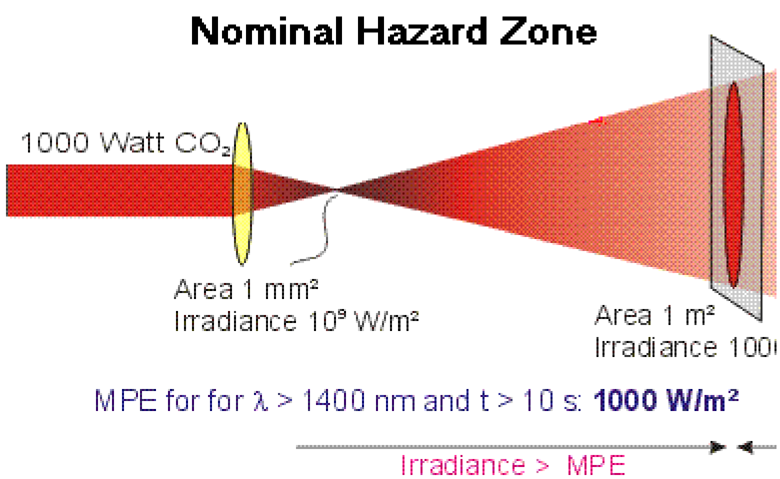
17. Maximum Permissible Exposure (MPE)

The Maximum Permissible Exposure (MPE) is defined as the level of laser radiation to which a person may be exposed without hazardous effects or adverse biological effects to the eye or skin. The MPE values are set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP; expressing MPE values as Exposure Limits (EL)) and are tabulated in units of J/m^2 or W/m^2. MPE values for the eye and skin differ, due to the specific optical and thermal properties of each. The most pronounced example of this occurs when considering MPE values in the retinal hazard wavelength region. On the basis of retinal damage thresholds and concentrations of light by the lens, maximum permissible exposure limits have been recommended by the American National Standards Institute (ANSI Z136.1). The MPE values for visible light are based on a pupil diameter of 7 mm, which is considered to be the maximum opening of the iris of the eye. For other wavelengths, the incident laser energy is averaged over a 1 mm diameter circle. The MPE values are below known hazardous levels. However, the MPE values may be uncomfortable to view. Thus, it is good practice to maintain exposure levels as far below the MPE values as practical.

18. Laser Work Environment

18.1. Identify the Hazard Zone – any area where potential laser exposure could result in an adverse biological effect to the eye or skin. Exposures below MPE values do not necessarily constitute safe levels. There is no conclusive evidence that supports a threshold exposure level below which no lesions are found and above which all exposures lead to damage.

18.2. Nominal Hazard Zone (NHZ) - The area which the level of the direct, scattered, or reflected radiation exceeds the applicable MPE. The purpose of a NHZ evaluation is to define the region where control measures are required.



18.3. Nominal Ocular Hazard Distance (NOHD) - The distance along the center axis of the unattenuated laser beam where the irradiance or radiant exposure is below the applicable MPE.

18.4. Laser Controlled Area (LCA) - The area which contains the NHZ, NOHD and the laser.

19. Laser Classification

The American National Standards Institute (ANSI) has established a laser hazard classification system in publication ANSI Z136.1 - 2014, *Safe Use of Lasers*. Certified laser manufactures are required to label their products as to the Class type as of September 19, 1985 (21 CFR Part 1040). Information regarding appropriate eyewear for a specific laser may be obtained from the manufacturer at time of purchase. The following table summarizes this laser classification scheme and the hazard capabilities associated with each class of laser.

Class	**Hazard Capabilities**
1	Incapable of producing hazardous conditions under normal operation. Exempt from control measures.
1M	Incapable of producing hazardous conditions under normal operation, unless aided viewing is used (e.g. telescope) and is exempt from control measures other than those produced by optical aids.
2	Operates in visible spectrum (400-700nm), eye protection is normally afforded by the aversion response (<0.25 seconds is not damaging to the eye).
2M	Operates in visible spectrum (400-700nm), eye protection is normally afforded by the aversion response (<0.25 seconds is not damaging to the eye) for unaided viewing. However, Class 2M is potentially hazardous if viewed with optical aids.
3R	Potentially hazardous under some direct and specular reflection viewing conditions if the eye is appropriately focused and stable, but the probability of an acute injury is small..
3b	Potentially hazardous under direct and specular viewing conditions, but normally not a fire hazard. Eye and skin damage will occur for direct, momentary intrabeam exposure.
4	Can damage the skin as well as the eye from direct beam, or exposure to diffuse reflections. Potential fire hazard, production of airborne contaminants or plasma radiation.

20. Laser Hazard Controls

20.1. The hazard controls necessary for the safe use of laser radiation depend upon the:

- laser classification
- environment where the laser is used
- laser operating characteristics
- persons operating the laser
- general population within the vicinity of the laser

20.2. Laser safety procedures can best be evaluated by grouping them according to the class of laser in use. The hazard evaluation should include consideration for laser systems that incorporate optical aids and specific to the laser application.

20.3. The control measures needed to eliminate or abate a hazard are influenced by several factors, such as:

- laser capability to cause a harmful effect
- laser radiation accessibility and Laser Controlled Area (LCA)
- qualifications of personnel working with laser or in LCA

20.4. Review of repeated incidents have demonstrated that accidental eye and/or skin exposures to laser radiation, and accidents related to the ancillary hazards of a laser or laser system, are most often associated with personnel involved with the use of these systems under the following conditions:

- Available eye protection not used
- Misaligned optics
- Equipment malfunction
- Improper method of handling high voltage
- Intentional exposure of unprotected personnel
- Operator unfamiliar with laser equipment
- Lack of protection for ancillary hazards
- Improper restoration of equipment following service
- Inadvertent beam discharge
- Insertion of flammable materials into beam path
- Unanticipated eye exposure during alignment

20.5. Class 1 Laser system – no controls required

20.6. Class 2 Laser System

20.6.1. Never permit a person to continuously stare into the laser source.

20.6.2. Never point the laser at an individual.

20.7. Class 3 Laser System

20.7.1. Do not aim the laser at an individual's eye.
20.7.2. Permit only experienced personnel to operate the laser.
20.7.3. Enclose as much of the beam path as possible. Even a transparent enclosure will prevent individuals from placing their head or reflecting objects within the beam path. Terminations should be used at the end of the useful paths of the direct beam and any secondary beams.
20.7.4. Shutters, polarizers and optical filters should be placed at the laser exit port to reduce the beam power to the minimal useful level.
20.7.5. A warning light or buzzer should indicate laser operation. This is especially needed if the beam is not visible, i.e., for infrared lasers.
20.7.6. Operate the laser only in a LCA - for example, in a closed room without windows. Place a warning sign on the door.
20.7.7. Place the laser beam path well above or well below the eye level of any sitting or standing observers whenever possible. The laser should be mounted firmly to assure that the beam travels only along its intended path.
20.7.8. Always use proper laser eye protection if a potential eye hazard exists for the direct beam or a specular reflection.
20.7.9. A key switch should be installed to minimize tampering by unauthorized individuals.
20.7.10. The beam or its specular reflection should never be directly viewed with optical instruments such as binoculars or telescopes without sufficient protective filters.
20.7.11. Remove all unnecessary mirror-like surfaces from the vicinity of the laser beam path. Do not use reflective objects such as credit cards to check beam alignment.

20.8. Class 4 Laser System

20.8.1. All controls listed for Class 3 laser systems also apply to Class 4 lasers.
20.8.2. should only be operated within a localized enclosure, in a controlled workplace, or where the beam is directed into outer space. If a complete local enclosure is not possible, indoor laser operation should be in a light-tight room with interlocked entrances to assure that the laser cannot emit energy while a door is open.

20.8.3. Appropriate eye protection is required for all individuals working within the LCA.

20.8.4. If the laser beam irradiance is sufficient to be a serious skin or fire hazard, a suitable shielding should be used between the laser beam and any personnel or flammable surfaces.

20.8.5. Remote firing with video monitoring or other remote (safe) viewing techniques should be chosen when feasible.

20.8.6. Outdoor high-power laser devices such as satellite laser transmission systems and laser radar should have positive stops on the azimuth and elevation traverse to assure that the beam cannot intercept occupied areas or non-target aircraft.

20.8.7. Beam shutters, beam polarizers, and beam filters should always be used to limit use to authorized personnel only. The flashlamps in optical pump systems should be shielded to eliminate any direct viewing.

20.8.8. Backstops should be diffusely reflective, fire resistant where feasible.

20.8.9. Microscopic viewing systems should ensure shielding to prevent hazardous levels of reflected laser radiation back through the optics.

20.9. Electrical Hazards

There have been several electrocutions in the U.S. from laser-related electrical accidents. These accidents could have been prevented. Contact EH&S if you have any questions concerning electrical safety. The following are general guidelines to prevent electrical shock:

- Avoid wearing rings, metallic watchbands and other metallic objects.
- When possible, only use one hand when working on a circuit.
- Assume that all floors are conductive when working with high voltage.
- Check that each capacitor is discharged, shorted and grounded before allowing access to the capacitor area.
- Inspect capacitor containers for deformities or leaks.
- Provide such safety devices as appropriate rubber gloves and insulating mats.
- Do not work alone.
- LSO approval is required to work on live electrical equipment.
- The requirements of the lockout/tagout program must be implemented as required.

21. Potential Laser Related Hazards

21.1. Optical:

21.1.1. primary beam: direct beam exposure, or scatter radiation to the eye or skin

21.1.2. aiming beam: direct beam exposure to the eye

21.2. Electrical: Electrical hazards are considered the most lethal when associated with laser use. It is possible for high voltage components to retain a charge after the power supply has been turned off. **Although electrical hazards are not normally present during laser operation, electrical safety awareness is a priority when modifications, alterations, installation, maintenance and servicing are conducted.**

21.3. Chemical: Lasing material used in laser systems (excimer, dye, chemical lasers) are potentially hazardous or toxic. Coolant systems on various laser systems (cryogenic coolant) can cause burns, explosions or displacement of oxygen. A material safety data sheet (MSDS) should accompany any chemical that is part of the laser system. Consult with Environmental Health & Safety to discuss chemical hazards in your area.

21.4. Solvents used in dye lasers are extremely flammable. Ignition may occur via high voltage pulses or flash lamps. Direct beams and unforeseen specular reflections of high-powered (>0.5 W) CW infrared lasers are capable of igniting flammable materials during laser operation. The construction material of beam enclosures, barriers and other objects are potentially flammable when exposed to high beam irradiance for more than a few seconds. Extreme caution must be used whenever oxygen is present during the laser procedure. Tests have been conducted on various masks and airway materials. Treatment areas should be prepared properly without the use of alcohol or acetone. Anesthetics administered either by inhalation or topically must be approved as non-flammable.

21.5. Associated non-beam: Associated hazards can include cryogenic coolant hazards, excessive noise from high powered systems, and ionizing radiations from high power laser systems.

21.6. Proper Lighting: Adequate lighting is necessary in controlled areas. If necessary, luminescent strips should be used. Proper illumination constricts pupils and thus indirectly limits the energy, which might inadvertently enter the eye.

21.7. Secondary ionizing and non-ionizing radiation production: Ionizing radiation that originates from the use of electrical power in excess of 15 kV. Microwave and radio frequency (RF) fields may be generated by laser systems or support equipment.

21.8. Explosion Hazards: Internal components such as arc lamps, filament lamps and capacitors may explode when reaching physical thresholds.

22. LCA Warning Signs and Posting Requirements

22.1. All laboratory postings and warning signs are provided by EH&S subsequent to the laser permit application process.

22.2. The purpose of the door posting is to convey a message that:

- 22.2.1. Provides an alert of a laser hazard in the area
- 22.2.2. Identifies a LCA that has been permitted by the LSO
- 22.2.3. Provides an alert of the NHZ and the associated severity of the hazard (classification, power or energy level, etc.)
- 22.2.4. Instructs personnel to take action to avoid exposure (eyewear required or other protective garment)
- 22.2.5. Provides the responsible person contact information

22.3. The laser sign signal words have the following meaning:

- 22.3.1. “DANGER” – Indicates an imminently hazardous situation, if not avoided, could result in death or serious injury. Limited to the most extreme conditions; restricted to Class 4 with high output power (e.g. multi kW) or energy.
- 22.3.2. “WARNING” - Indicates an imminently hazardous situation, if not avoided, could result in death or serious injury.
- 22.3.3. “CAUTION” – Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

22.4. All signs shall be conspicuously posted to warn personnel.

23. Protective Eyewear

ANSI Z136.1 requires that protective eyewear be available and worn whenever hazardous conditions may result from laser radiation or laser related operations. The eye may be protected against laser radiation by the use of protective eyewear that attenuates the intensity of laser light while transmitting enough ambient light for safe visibility (luminous transmission). The ideal eyewear provides maximum attenuation of the laser light while transmitting the maximum amount of ambient light. No single lens material is useful for all wavelengths or for all radiation exposures. In choosing protective eyewear, careful consideration must be given to the operating parameters, MPEs, and wavelength. The Laser Safety Officer (LSO) will recommend the appropriate laser safety eyewear during the laser registration process.
Persons working with lasers emitting in the visible region are often unwilling to wear protective eyewear during alignment procedures due to the inability to see the beam. Laser alignment goggles are available which provide acceptable protection during reduced power alignment procedures while allowing an outline of the beam to be seen. Appropriate eyewear information may be acquired for a particular laser from the manufacturer at the time of purchase. Insight as to proper and reasonable eye protection may also be obtained from the LSO.
It is extremely important that laser workers wear the appropriate laser safety eyewear correctly. For example, only eyewear such as goggles specifically designed to fit over prescription glasses may be worn with prescription glasses. Other protective eyewear worn over prescription glasses may not provide complete eye protection.

24. General Safety Procedures

24.1. Do not work with or near a laser unless you have been authorized to do so.

24.2. Do not enter a room or area where a laser is be energized unless authorized to do so.

24.3. Before energizing a laser, verify that prescribed safety devices for the unit are properly employed. These may include opaque shielding, non-reflecting and/or fire-resistant surfaces, goggles and/or face shields, door interlocks, and ventilation for toxic material.

24.4. Make sure that a pulsed laser unit cannot be energized inadvertently. Discharge capacitors and turn off power before leaving the laser unit unattended.

24.5. Don't stare directly into the laser beam. Use appropriate eyewear during beam alignment and laser operation. Beam alignment procedures should be performed at lowest practical power levels.

24.6. Control the access to the laser facility. Implement access control by locking the door and installing warning lights and signs on the outside door.

24.7. Never leave an energized laser unattended.

24.8. Minimize specular surfaces in the NHZ. Remove any jewelry and remove unnecessary specular objects form the work environment.

25. Specific Safety Procedures

25.1. Beam Alignment

It is clear in the literature that most laser injuries occur during beam alignment procedures. These procedures require exact positioning of the beam, and too often those performing the alignment do not wear their laser protective eyewear. It is often the case, as well, that this accident scenario results most when people are working with visible beams. This is because beam alignment with infrared and ultraviolet lasers requires the use of indirect viewing of the beam, for example with IR or UV sensitive cards in the beam path. It is also clear from the literature that people like those at Tufts University, students, faculty, technicians, and scientists involved in research uses of lasers, represent a large portion of the number of people injured in laser accidents.

All of this means that laser workers, especially those working with visible beams and performing alignment procedures, have a higher potential for injury. It is obvious that wearing laser protective eyewear can minimize the actual level of risk, and this is particularly true during alignment procedures. Special alignment glasses are available for those that feel it is necessary to remove their protective glasses while doing precision alignment with visible beams. Alignment glasses allow for a small percentage of the beam to be seen when it strikes targets, while filtering out the greater percentage of the beam that could cause injury upon exposure. All workers should consider the use of alignment glasses to prevent injury.

In some cases, alignment glasses will not work or they may not be available for purchase. In these cases, the regular laser protective eyewear must be worn and indirect methods of viewing the beam path must be used. In addition, many lasers may have their beam intensity reduced during alignment procedures. This power reduction may actually allow the alignment without laser protective eyewear, but only when calculations or measurements or other verification methods prove that the beam intensity is below the injury threshold. It is unacceptable to perform any laser work that may involve exposure in excess of the maximum permissible exposure limits without laser eye protection. Please see **Appendix A** for a comprehensive description of beam alignment safety practices.

25.2. High Powered Pulsed Class 4 Lasers

25.2.1. Safety interlocks at the entrance of the laser facility should be constructed so that unauthorized or transient personnel are denied access to the facility while the laser power supply is charged and capable of firing.

25.2.2. The alarm system including muted sound, flashing lights (visible through laser safety eyewear) and a countdown procedure should be used once the capacitor banks begin to charge.

25.2.3. Walls and ceilings should be painted with non-reflective paint to produce a diffuse surface. Diffuse black is preferred in the target area, and a light color in the surrounding area to maximize the lighting distribution from general lighting fixtures.

25.3. Low Powered CW gas and semiconductor

25.3.1. General precautions with reference to aiming and the avoidance of specular reflection should be observed.

25.3.2. The laser beam should be terminated at the end of its useful beam path by a material that is a diffuse matte of such color or reflectivity to make positioning possible but should minimize the reflection.

25.3.3. Reflective material should be eliminated from the beam area, and good housekeeping should be maintained.

25.4. Carbon Dioxide-Nitrogen Gas Lasers

25.4.1. Since the output from CO_2-N_2 lasers is invisible infrared radiation, specific precautions are needed to prevent accidental thermal burns and ignition of flammable materials.

25.4.2. Precautions should include exclusion of personnel from the path of the beam and stopping the beam with such materials as firebrick.

25.4.3. The laser assembly should be constructed of a material opaque to ultraviolet light generated by the gas discharge.

25.4.4. Reflections of the infrared laser beam should be controlled by enclosure of the beam and target area or when necessary by requiring personnel to wear full-face shields. (Plexiglass face shields effectively attenuate CO_2 laser radiation).

25.5. Gas Lasers Using Chlorine or Fluorine

25.5.1. Users should be aware of the extreme toxicity of chlorine and fluorine gases. Concentrations as low as 0.1 ppm of fluorine are considered toxic. Gases should be stored in such a way as to ensure proper ventilation to minimize the potential for exposure.

26. Attachment A: "Laser System Permit Application"

LSP-001 Laser System Permit Application GS 3/13

Tufts University School of Medicine

SECTION 1: GENERAL INFORMATION	
☐ New ☐ Amendment ☐ Renewal	Return to: Tufts University Radiation Safety Office 200 Harrison Avenue 105 Posner Hall Boston, MA 02118 Email to: geoff.sirr@tufts.edu

Principal Investigator

(Last) (First) (M.I.) Suffix

Additional Information:

Department Position Campus Telephone

Email address

Office Location:

Building Room Street Address

SECTION 2: INVENTORY OF ANSI CLASS 3B and 4 LASERS

Manufacturer	Model	Serial Number	Class	Lasing Medium
1.			☐3B ☐4	
2.			☐3B ☐4	
3.			☐3B ☐4	

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LSP-001 Laser System Permit Application GS 7/10

4.			☐3B ☐4	
5.			☐3B ☐4	
6.			☐3B ☐4	
7.			☐3B ☐4	
8.			☐3B ☐4	
9.			☐3B ☐4	
10.			☐3B ☐4	
11.			☐3B ☐4	
12.			☐3B ☐4	

SECTION 3: AREA Of USE

Please provide the associated information for each numbered laser system in Section2

#	Building	Room #	Power or energy output & wavelength
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

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LSP-001 **Laser System Permit Application** GS 7/10

SECTION 4: TRAINED PERSONNEL

List all personnel (including applicant and contact person) who will be working with laser systems as authorized by this permit.

Last Name	First Name	This person has received training and / or has experience working with lasers.		If Yes, was this individual trained by Tufts University Radiation Safety?	
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐
		Yes ☐	No ☐	Yes ☐	No ☐

SECTION 5: CONFIRMATION & SIGNATURE

I have received, read, understand, and agree to follow the requirements of the Tufts University Laser Safety Manual (http://publicsafety.tufts.edu/ehs/downloads/LaserSafetyProgram2005.pdf).

____

Signature of the Applicant Date

____

Signature of Department Chairperson Date

Laser System Permit's are reviewed by the Laser Safety Officer. Subsequent to the permit application and review process, an inspection of the laboratory and the associated equipment is conducted jointly with the applicable Principal Investigator or his/her delegate.

Page **3** of **4**

LSP-001 Laser System Permit Application GS 7/10

Radiation Safety Use Only
SECTION 6: LASER SYSTEM PERMIT #

Permit Type: New: ☐ **Amendment:** ☐ **Renewal:** ☐

Effective Date: **Expiration Date:**

Principal Investigator

(Last) (First) (M.I.) Suffix

Department Campus Telephone

Date Application Received	Date Approved by RSO	Date Ratified by RHCG

______________________________ ____/____/____
Signature of Laser Safety Officer Date

Comments:

Page **4** of **4**

27. Attachment B: "Example Standard Operating Procedures"

(SAMPLE SOP – use as a guideline for developing your laboratory SOP)

CLASS 3b & 4 LASERS Procedure

1. USER REQUIREMENTS PRIOR TO OPERATING THE LASER

    a. Attend a laser safety lecture provided by TEHS.
    b. Read and understand the standard operating procedure for the LASER.
    c. Demonstrate the understanding and skill required to use the LASER in the presence of the supervisor responsible for the laser.

2. INFORMATION TO BE POSTED WITH LASER

    a. Supervisor name __________________Contact # _______________
    b. Laser maintenance (contact) ________________Contact # _______
    c. List of emergency contacts
        i. ___________________
        ii. ___________________
        iii. ___________________
    d. Laser eye protection required ____________________ (include optical density and wavelength range).

3. LASER APPLICATION AND SPECIFIC HAZARD CONSIDERATIONS

    a. Refer to information located in ______________.

4. PROCEDURES FOR LASER OPERATION
    a. Sign the logbook (if appropriate).
    b. Make sure the entrances to the area are posted "LASER in Use".
    c. Turn on the LASER warning light.
    d. Give verbal notification to personnel in the area.
    e. Turn on the heat exchanger (if applicable)
    f. Turn on the cooling water for the LASER (if applicable)
    g. When working in an area where the beam is exposed, remove any jewelry, watches or other highly reflective articles of clothing
    h. Examine the beam path and look for misaligned mirrors and other items which could misdirect the laser radiation.
    i. Use appropriate eye protection.
    j. Close the LASER shutter.
    k. Turn on the LASER power supply.
    l. Turn on the LASER.
    m. Open LASER shutter.
    n. Any time full power is not needed turn LASER power down to its lowest level.
    o. Never leave the LASER unattended while it is in operation.

5. PROCEDURES FOR LASER SHUTDOWN
    a. Close the LASER shutter.
    b. Turn off the LASER.
    c. Turn off LASER power supply.
    d. Wait 3-5 minutes for final waste heat removal.
    e. Turn off heat exchanger and water supply (if applicable).
    f. Turn off warning lights.
    g. Remove “LASER in Use” posting.
    h. Sign log book (if applicable).

6. ALIGNMENT PROCEDURE
    a. See Manufacturer Instructions located in ______________

28. References

a. Massachusetts Department of Public Health Radiation Control Program; 105 CMR 121.000

b. American National Standards Institute (ANSI) Z136.1 – 2014

c. LIA Laser Safety Guide (Tenth Edition)
by Editor-Wesley Marshall, Wesley Marshall, David H. Sliney
Published 2000

d. Safety with Lasers and Other Optical Sources: A Comprehensive Handbook (First Edition)
by David Sliney, Myron Wolbarsht