Laser Safety

Due to the growing use of lasers on campus, the Radiation Safety Office has developed the following laser safety information, which includes selected requirements for University students, staff or visitors using or observing any lasers or laser facilities. Please consult the Florida Administrative Code 64E-4.001.016 for a complete listing of rules and regulations governing the use of lasers at Florida State University. This program is designed to manage the use of lasers on campus and to control the hazards associated with their use. For more information, contact the Radiation Safety Office at 644-8802.

Laser Classes

Below, the main characteristics and requirements for the classification system as specified by the IEC 60825-1 standard are listed. Additionally, classes 2 and higher must have the triangular warning label and other labels are required in specific cases indicating laser emission, laser apertures, skin hazards, and invisible wavelengths. For classes I to IV, see the Old System of Laser Classification.

Class 1

A class 1 laser is safe under all conditions of normal use. This means the maximum permissible exposure (MPE) cannot be exceeded.

Class 1M

A Class 1M laser is safe for all conditions of use except when passed through magnifying optics such as microscopes and telescopes. Class 1M lasers produce large-diameter beams, or beams that are divergent. The MPE for a Class 1M laser cannot normally be exceeded unless focusing or imaging optics are used to narrow the beam. If the beam is refocused, the hazard of Class 1M lasers may be increased and the product class may be changed. A laser can be classified as Class 1M if the total output power is below class 3B but the power that can pass through the pupil of the eye is within Class 1.

Class 2

A Class 2 laser is safe because the blink reflex will limit the exposure to no more than 0.25 seconds. It only applies to visible-light lasers (400–700 nm). Class-2 lasers are limited to 1 mW continuous wave, or more if the emission time is less than 0.25 seconds or if the light is not spatially coherent. Intentional suppression of the blink reflex could lead to eye injury. Many laser pointers and measuring instruments are class 2.

Class 2M

A Class 2M laser is safe because of the blink reflex if not viewed through optical instruments. As with class 1M, this applies to laser beams with a large diameter or large divergence, for which the amount of light passing through the pupil cannot exceed the limits for class 2.

Class 3R

A Class 3R laser is considered safe if handled carefully, with restricted beam viewing. With a class 3R laser, the MPE can be exceeded, but with a low risk of injury. Visible continuous lasers in Class 3R are limited to 5 mW. For other wavelengths and for pulsed lasers, other limits apply.

Class 3B

A Class 3B laser is hazardous if the eye is exposed directly, but diffuse reflections such as from paper or other matte surfaces are not harmful. Continuous lasers in the wavelength range from 315 nm to far

infrared are limited to 0.5 W. For pulsed lasers between 400 and 700 nm, the limit is 30 mW. Other limits apply to other wavelengths and to ultra short pulsed lasers. Protective eyewear is typically required where direct viewing of a class 3B laser beam may occur. Class-3B lasers must be equipped with a key switch and a safety interlock.

Class 4

Class 4 lasers include all lasers with beam power greater than class 3B. By definition, a class-4 laser can burn the skin, in addition to potentially devastating and permanent eye damage as a result of direct or diffuse beam viewing. These lasers may ignite combustible materials, and thus may represent a fire risk. Class 4 lasers must be equipped with a key switch and a safety interlock. Most industrial, scientific, military, and medical lasers are in this category.

Responsibilities

Principal Investigator

The Principal Investigator (PI) is responsible for the safe use of lasers in the PI's laboratory. The PI must notify the Radiation Safety Office upon purchasing a class 3B or 4 laser device. The PI must notify the Radiation Safety Office of any changes in the operational status, such as location changes and or modifications to any laser equipment that may change the classification number. The PI may assign each laser facility a Laboratory Laser Safety Officer (LLSO), who has the proper training and background to perform this function or the PI will be the default LLSO. The LLSO is responsible for:

- Ensuring the proper registration of all class 3b and 4 lasers and personnel who will operate the lasers.
- Ensuring that all personnel have been provided Lab-Specific Laser Training by qualified lab personnel.
- Developing, maintaining, and updating, as needed, all operating, alignment, and emergency procedures (SOP's) for the lasers and facility under the LLSO's control.
- Acting as the contact for the Radiation Safety Office.
- Enforcing the safety standards defined in the FSU Laser Safety policy.
- Supervising all spectators, visitors and personnel with access to the facility to ensure against unauthorized entrance or accidental exposure to laser radiation.
- Updating all records to reflect changes in personnel or equipment by contacting the Radiation Safety Office.
- Reporting all incidents involving safety violations or injury to the Radiation Safety Office at 644-8802.
- Ensuring that all personal protective equipment is properly maintained.

Laser Operators

The individual user (laser operator) must observe all safety precautions and operating procedures while using class 3B or 4 lasers and shall inform the PI, LLSO, FSU Laser Safety Officer (LSO) or FSU Radiation Safety Officer of any apparent safety problems associated with the use of the laser. The laser operator shall be responsible for:

- Following laboratory administrative, alignment, and SOP's while operating lasers and reading safety instructions in laser equipment operator's manuals.

- Keeping the PI fully informed of any departure from established safety procedures. This includes notification of an exposure incident.
- Become knowledgeable about all aspects of laser operation by obtaining Lab-Specific Laser Safety Training from qualified laboratory personnel.

Environmental Health & Safety

The Florida State University Department of Environmental Health and Safety has designated a University Laser Safety Officer (LSO) to coordinate compliance efforts with chapter 64E-4, FAC. The LSO or the Radiation Safety Officer (RSO) have jurisdiction over all aspects of hazard prevention and control of laser radiation and have the authority to suspend any operation that constitutes a radiation health hazard to the equipment operators, University personnel, or the general public. The University LSO will:

- Conduct lab inspections to ensure that safety requirements are followed.
- Review and submit all laser SOP's to the Laser Safety and Policy Committee for approval.
- Authorize laser lab use areas.
- Provide assistance in evaluating and controlling hazards.
- Update online safety resources when necessary.
- Maintain all records of lasers and laser operators.
- Ensure the provision of laser safety training for personnel who are assigned to an area where lasers are operated.
- Participate in accident investigations involving lasers.
- Coordinate a Laser Safety and Policy Committee (LSPC) and biannual committee meetings.

Laser Safety and Policy Committee

The Laser Safety and Policy Committee (LSPC) was established for the purpose of acting as an advising and approval panel for the laser safety program. The program is designed to manage the use of lasers on campus, and to control the hazards associated with their use. The committee also serves to evaluate any state or federal regulations that affect the users of lasers at Florida State University.

The LSPC is made up of four members; the LSO and three Principal Investigators or Co investigators trained and experienced in the safe use of lasers. The Chairperson is appointed from one of the three selected members. There is no routine rotation of Committee members.

The scope of the Committee's jurisdictions includes the FSU campus and approved off campus sites. The Committee has the overall responsibility for the laser safety program to ensure compliance with all local, state and federal regulations and guidelines. Specific duties of the LSPC include:

- Determine and approve all policies regarding the laser safety program.
- Review and approve all laser SOP's submitted by PI's.
- Act as technical advisor to the LSO.
- Revoke operator's privilege in case of serious and repeated violations of regulations.
- Prescribe special conditions, as may be necessary, such as additional training and/or instructions, designated or limited use areas, etc.
- Review all state laser regulations to determine their impact on the FSU community.

- Review all reports that are submitted to the committee by the LSO.
- Any member may call meetings at any time.

Laser Registration

All class 3B, 3R, and 4 lasers must be properly registered with the Radiation Safety Office prior to installation and use. Registration is accomplished online by filling out and submitting the FSU Laser Registration form (an FSUID is required to access the form).

All laser workers must be registered with the Radiation Safety Office prior to using any laser. Registration is accomplished by notifying this office, via memorandum, of the names and work locations of these individuals.

All newly registered lasers and facilities must be inspected and approved for operation by the University's LSO prior to beginning laser operations. Contact the Radiation Safety Office at 644-8802 for approval.

Personal Protective Equipment

Eye Protection

The Principal Investigator or Laboratory Laser Safety Officer who operate or supervise the operation of a laser are responsible for determining the need for laser eye protection for a particular laser. If required, eye protection will be provided for staff and visitors to the area. EH&S can provide assistance in eyewear selection.

Simplified Method for Selecting Laser Eye Protection for Intrabeam Viewing for Wavelenghts between 400-1400 nm.**

Q-Switched Lasers (10^{-9} - 10^{-2} s)		**Non-Q-Switched Lasers ($0.4x10^{-3}$ - 10^{-2} s)**		**Continuous-Wave Lasers Momentary (0.25 - 10 s)**		**Continuous-Wave Lasers Momentary (less than 1 h)**		**Attenuation**	
Maximum Output Energy ($J•cm^2$)	Maximum Beam Radiant Exposure (J)	Maximum Output Energy ($J•cm^2$)	Maximum Beam Radiant Exposure (J)	Maximum Power Output (W)	Maximum Beam Irradiance ($W•cm^2$)	Maximum Power Output (W)	Maximum Beam Irradiance ($W•cm^2$)	Attenuation Factor	OD
10	20	100	200	10^5 *	2 x 10^5 *	100*	200*	100000000	8
1	2	10	20	10^4 *	2 x 10^4 *	10*	20*	10000000	7
10^{-1}	2 x 10^{-1}	1	2	10^3 *	2 x 10^3 *	1	2	1000000	6
10^{-2}	2 x 10^{-2}	10^{-1}	2 x 10^{-1}	100*	200*	10^{-1}	2 x 10^{-1}	100000	5
10^{-3}	2 x 10^{-3}	10^{-2}	2 x 10^{-2}	10	20	10^{-2}	2 x 10^{-2}	10000	4

10^{-4}	2 x 10^{-4}	10^{-3}	2 x 10^{-3}	1	2	10^{-3}	2 x 10^{-3}	1000	3
10^{-5}	2 x 10^{-5}	10^{-4}	2 x 10^{-4}	10^{-1}	2 x 10^{-1}	10^{-4}	2 x 10^{-4}	100	2
10^{-6}	2 x 10^{-6}	10^{-5}	2 x 10^{-5}	10^{-2}	2 x 10^{-2}	10^{-5}	2 x 10^{-5}	10	1
*Not recommended as a control procedure at these levels. These levels of output power could damage or destroy the attenuating material used in eye protection. The skin also needs protection at these levels.									
**Use of this table may result in optical densities (OD) greater than necessary. See ANSI Z136.1-2000, section 4.6.2 for other wavelengths.									
Reproduced with permission from LIA Guide for the Selection of Laser Eye Protection, 5th edition. 									

Body Protection

Protective gloves and clothing must be worn during the operation of Class 4 lasers, where the possibility exists for laser injury to parts of the body other than the eyes.

Posting Laser Use Areas

All laser use areas containing Class 3 or greater lasers shall be posted with the appropriate signs. Class 1 and Class 2 laser facilities are not required to be posted. Use the following guidelines for posting of Class 3 and Class 4 lasers:

- Facilities containing Class 3a and 3B lasers shall have postings at every entrance which contain the text "VISIBILE AND/OR INVISIBLE LASER RADIATION- AVOID DIRECT EXPOSURE TO BEAM", "CLASS 3a LASER PRODUCT" or "CLASS 3b LASER PRODUCT".
- Facilities containing Class 4 lasers shall have postings at every entrance, which contain the text "LASER RADIATION- AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION", "CLASS 4 LASER PRODUCT".
- Postings may be obtained from the Radiation Safety Office or a safety supply vendor.

Laser Safety Rules

The general rules below are to be followed by all personnel, visitors, and spectators to ensure maximum safety.

- The minimum laser radiant energy or laser power level required for the application should always be used.
- Emergency response procedures must be in plain view in all laser facilities.
- All facilities must have an openly available set of operating procedures (SOPs) for each individual laser.
- A qualified technician must perform servicing for a laser or laser system.
- Lasers are to be operated in well-lighted areas, if at all possible, to minimize possible eye damage.
- Flash lamps used with solid state lasers should be shielded.

- Never leave an operating laser unattended and never work alone in the facility while operating a laser, especially after normal working hours.

To minimize direct eye exposure, observe these precautions:

- Do not intentionally look directly into laser beam or at specular reflection, regardless of its power.
- Minimize specular reflection.
- Terminate beam at end of its useful path.
- Clearly identify the beam path(s) and ensure that they do not cross populated areas or traffic paths.
- Locate the beam path at a point other than eye level when standing or when sitting at a desk.
- Orient the laser so that the beam is not directed toward entry doors or aisles.
- Securely mount laser systems on a stable platform to maintain the beam in a fixed position during operation and limit beam traverse during adjustments and alignments.
- Jewelry must not be worn in a controlled laser area.
- Visual alignment of laser systems while the laser is operating should not be attempted. If possible, lasers should be powered down during alignment.

Specific Safety Requirements for Class 1,2,3, or 4 Lasers

Each laser and laser facility must be designed to ensure that maximum protection is afforded to the operator. Control measures shall be devised and taken to ensure minimal exposure to the eyes and skin from hazardous laser radiation.

Class 1 Lasers

- Class 1 lasers require no controls, though it is advisable not to needlessly expose the eyes to direct Class 1 laser radiation.
- If the laser has not been labeled by the manufacturer, attach a label on the laser with its classification and relevant warning information.

Class 2 Lasers

- Class 2 lasers require an affixed housing or control panel and appropriate warning labels. These labels shall include "Caution- AVOID EXPOSURE" label near the aperture and a Class 2 warning logo for class 2 pulse lasers.

Class 3M, 3B, and Class 4 Lasers

A permanent laser controlled area must be established for all class 3b and 4 lasers and laser facilities and must meet the following criteria:

- Each area must be under the direct supervision of the Principal Investigator or (PI) or Laboratory Laser Safety Officer (LLSO).
- Access to the area must be supervised. The entrance to the doors must be closed at all times. There should be a barrier between the door and laser area.
- The area must have appropriate signs posted.

- All potentially hazardous beams in the area must be terminated in an appropriate beam stop.
- A panic button or control-disconnect switch must be available to deactivate the laser in the event of an emergency in the area.
- All optical paths that can allow the beam to exit the control area must be covered or restricted in a manner that prevents transmission of laser radiation.
- If a beam is to exit the controlled area, the LLSO shall ensure the beam path is limited to controlled air space.

All Class 3M, 3B, and Class 4 lasers require the follow controls:

- Protective eyewear designed for the specific laser being used must be worn by all individuals having access to Class 3M, 3b, or 4 laser radiation during operation. Protective gloves, clothing and shields must also be worn, as appropriate, when the possibility exists for laser injury to parts of the body other than the eyes.
- All protective housings must remain in place to prevent exposure from any source other than the defined aperture unless the protective housing interferes with necessary laser operation.
- The protective housing must be interlocked to prevent exposure of personnel to unnecessary laser radiation. Interlocks must be checked during routine inspections to ensure they are functioning properly. The interlock must not be overridden during normal operation.
- Laser interlocks shall be designed to prevent firing of the laser. This shall be accomplished by an interlock that disables the power supply or interrupts the beam (for example, shutters). Class 3B and 4 must be provided with a key-switch interlock that, when removed, prevents the operation of the laser, and disables the power supply.
- Adjustments or servicing shall not cause an interlock to become inoperative or allow radiation outside the protective housing unless a laser control area is established.
- If interlocks must be bypassed during maintenance, a temporary Laser Control Area must be established.
- A master switch (either a key or coded access) must be provided that, when removed, must make the laser inoperable. Authority for access to the master switch must be with the PI and/or the LLSO.
- Since viewing portals and collecting optics may increase the hazards, all devices must incorporate a means to maintain laser radiation emitted through them at or below safe levels. The LLSO shall determine the potential hazard and take proper safety measures.
- Beam stops or attenuators must be permanently attached and capable of preventing output emission when the laser is on standby.
- If at all possible, the interaction area, that is the area where the primary beam or secondary beam irradiates the sample material, should be enclosed and equipped with a safety interlock so that the laser cannot be operated unless the interlock is in place.
- If possible, all Class 4 lasers with exposed beam paths should be fired remotely.
- All lasers must have an "Avoid Exposure" label near the aperture, a warning label on the laser in accordance with Control of Non-ionizing Radiation Hazards, Chapter 64E-4.3a(6), FAC, and warnings posted in or around the laser facility.

- Disconnection of fiber optics must take place in a laser-controlled area.
- If any engineering controls listed above cannot be accomplished, or will impede the nature of the research, administrative controls should be formulated by the PI and submitted to the Laser Safety Committee for approval.

Exposure Reporting and Emergency Response Procedures

If an exposure incident occurs, the Radiation Safety Office must be notified as soon as is possible. If the incident causes an injury or could potentially have caused an eye injury, the person(s) who received an exposure should inform his/her supervisor and have an eye exam performed, if necessary. During normal business hours (8:00 a.m. to 4:30 p.m. work days) call the Radiation Safety Office at 644-8802. After normal working hours, weekends or holidays, call the FSU Police at 644-1234, 911, or use an emergency telephone. Provide the following minimal information:

- Your name;
- Building and location;
- Estimated seriousness of incident/injury.

Stay on the line until all necessary information has been provided. If you called FSU Police, they will notify the FSU Department of Environmental Health and Safety and the appropriate emergency response personnel.

If the Radiation Safety Officer cannot be reached, other Radiation Safety personnel or a member Environmental Health and Safety must be notified by calling 644-6895.

Obtaining Medical Care – Reporting an Injury

See Workers' Compensation

See Lab Accident Flowchart

Converting to a Class 1 Enclosure

Any laser or laser system can be converted to a Class 1 enclosed laser by including all of the following controls in the laser system design. These controls will effectively enclose the laser, thus preventing personnel contact with emitted laser radiation while permitting unrestricted access into the area.

Protective Housing

- House the laser system within a protective enclosure to prevent the escape of laser radiation above the maximum permissible exposure (MPE).
- The protective housing must prevent personnel access to the laser system during normal operations.
- Personnel entering the enclosure to perform maintenance or adjustment tasks must be made aware of the higher risk laser class.

Safety Interlocks

- Install safety interlocks wherever the protective enclosure can be opened, removed or displaced.
- When activated, these interlocks must prevent a beam with radiant energy above the maximum permissible exposure (MPE) from leaving the laser or lasing system.

- Service adjustments or maintenance work performed on the laser system must not render the interlocks inoperative or cause exposure levels outside the enclosure to exceed the MPE, unless work is performed in a laser area with limited access and appropriate safeguards.

Fail-Safe Design

- The protective enclosure and the laser system must be designed and fabricated so that if a failure occurs, the system will continue to meet the requirements for an enclosed laser operation.
- Modifications to commercial laser systems must be evaluated. Contact the University Laser Safety Officer for an evaluation. If modifications decrease the safety controls, a revised SOP will be required.

Attenuated Viewing Window

- Use viewing windows containing a suitable filter material that will attenuate the transmitted laser radiation to levels below the MPE under all conditions of operation.

Warning Signs and Labels

- Label the enclosure with "Caution-Enclosed Laser" signs.
- Attach a label directly to the laser that gives the laser classification in the absence of an enclosure. Make sure that the laser label can immediately be seen when the enclosure is opened.

Controlling Associated Hazards

Many chemical and physical hazards other than laser radiation can be found in the laser area that must also be adequately controlled.

Electrical Equipment and Systems

- Always be aware of the high risk of injury and fire during laser operations because of the presence of electrical power sources.
- The installation, operation, and maintenance of electrical equipment and systems must conform to standards stated in the National Electric Code (NFPA 70-2002). Contact EH&S for assistance.

Lighting

- Adequate lighting is necessary in controlled areas.
- If lights are extinguished during laser operation, provide control switches in convenient locations or install a radio-controlled switch.
- Luminescent strips/tape should be used to identify table and equipment corners, switch locations, aisles, etc.
- When ambient light is not sufficient for a safe egress from a laser area during an electrical power failure, install emergency egress lighting.

Ionizing and Non-ionizing Radiation

- A laser operation may involve ionizing radiation that originates from the presence of radioactive materials or the use of electrical power in excess of 15kV.

- If radioactive material is present in the laser system, "Caution- Radioactive Material" signs must be prominently displayed. If X-rays are generated a "Caution-X-Rays" sign must be posted.
- Microwave and radio frequency (RF) fields may be generated by laser systems or ancillary equipment.
- Contact the Radiation Safety Office at 644-8802 for evaluation of these hazards before starting an operation.

Hazardous Materials

- Bring into the laser area only those hazardous materials that are essential for the operation or experiment.
- All hazardous materials must be properly used, stored and controlled. Consult Safety Data Sheets (SDS) and EH&S for information and refer to Chemical Safety.
- Do not allow laser beams and strong reflections to impinge on combustible materials, explosives, highly flammable liquids or gases or substances that decompose into toxic products under elevated temperatures, without providing adequate controls.
- Conduct or sponsor tests that establish the effects of beam interactions with hazardous materials. Findings can be used to determine safe parameters for laser operation.

Dyes and Solutions

- Dye lasers normally use a lasing medium composed of complex fluorescent organic dye dissolved in an organic solvent. These dyes vary greatly in toxicity, mutagenicity, and potential carcinogenicity.
- All dyes must be treated as hazardous chemicals. Most solvents suitable for dye solutions are flammable and toxic by inhalation and/or skin absorption.
- Obtain SDS sheets from the manufacturer for all dyes and solvents or refer to resources provided in Chemical Safety.
- Use and store all dyes and solvents in accordance with SDS sheets.
- Prepare and handle dye-solutions inside a chemical fume hood.
- Wear a lab coat, eye protection, and gloves.
- Pressure test all dye laser components before using dye solutions. Pay close attention to tubing connections.
- Install spill pans under pumps and reservoirs.
- Keep dye-mixing areas clean.

References

- American National Standards Institute, Inc., American National Standards for the Safe Use of Lasers, Z136.1-2000
- American National Standards Institute, Inc. American National Standard for Safe Use of Lasers in Educational Institutions, Z136.5-2000
- Florida Administrative Code, Control of Non-Ionizing Radiation Hazards, Chapter 64-E4.001-.016

- US Code of Federal Regulations: 29 CFR Part 1040.10, Laser Products
- Nikon Mircoscopy Laser Safety
- Kentek Safety Glasses (EH&S does not endorse a particular vendor for protective products)