

The University of Tennessee, Knoxville
LASER SAFETY PROGRAM

SCOPE

The University of Tennessee has the responsibility to ensure the safe use of lasers owned and/or operated in its facilities. The following document describes the university's laser safety program. This program applies to Class 3B or 4 lasers, or for Class 3B or 4 lasers where beam access by persons is required during maintenance or service operated on University of Tennessee Knoxville Area campuses. This program is based on guidance of ANSI Z136.1-2014, *American National Standard for Safe Use of Lasers*.

LASER SAFETY OFFICER

The university will designate an individual as the Laser Safety Officer (LSO) that has the responsibility and authority to affect the knowledgeable evaluation and control of laser hazards, as well as to monitor and enforce compliance with required standards and regulations. Throughout the body of this program description, it shall be understood that wherever duties or responsibilities of the LSO are specified, it will mean that the LSO either performs the stated task or ensures that the task is performed by a qualified individual.

The LSO shall have final authority in determining laser control measures and may approve alternate controls when these are appropriate based on the judgment of the LSO. Class 3B and class 4 lasers shall be operated only with the approval on the LSO. The LSO shall have the authority to suspend, restrict, or terminate the operation of a laser system if he/she deems that the laser hazard controls are inadequate.

LSO Specific Duties and Responsibilities.

- 1. Safety Program.** The LSO shall establish and maintain adequate policies and procedures for the control of laser hazards. These policies and procedures shall comply with applicable requirements including federal, state and local regulations.
- 2. Classification.** The LSO shall classify or verify classifications of lasers and laser systems used under the LSO's jurisdiction.
- 3. Hazard Evaluation.** The LSO shall be responsible for hazard evaluation of laser work areas.
- 4. Control Measures.** The LSO shall be responsible for ensuring that the prescribed control measures are implemented and maintained in effect.
- 5. Procedure Approvals.** The LSO shall approve Class 3B and Class 4 SOPs and other procedures that may be part of the requirements for administrative and procedural controls.
- 6. Protective Equipment.** The LSO shall recommend or approve protective equipment, such as eyewear, clothing, barriers and screens that may be required to

- ensure personnel safety. The equipment will be audited periodically to assure proper working order.
7. **Facility and Equipment.** The LSO shall review the wording on area warning signs and equipment labels and review Class 3B and Class 4 laser installations, facilities and laser equipment prior to use. This also applies to modification of existing facilities or equipment.
 8. **Training.** The LSO shall ensure that adequate safety education and training are provided to laser personnel. The LSO and/or a qualified designee shall participate in professional trainings and/or conferences to maintain their knowledge and skill level.
 9. **Medical Examination.** The LSO shall require medical examinations when necessary.
 10. **Records.** The LSO shall ensure that the necessary records required by applicable government regulations are maintained.
 11. **Audits, Surveys and Inspections.** The LSO shall periodically audit or survey by inspection for the presence and functionality of the laser safety features and control measures required for each Class 3B and Class 4 laser or laser system in the laser facilities. The LSO shall ensure that corrective action is taken, when required.
 12. **Accidents.** The LSO should develop a plan to respond to notifications of incidents of actual or suspected exposure to potentially harmful laser radiation.
 13. **Approval of Laser Systems Operations.** Approval of a Class 3B or Class 4 laser or laser system for operation shall be given if the LSO and, at the LSO's discretion, *the laser safety committee* are satisfied that laser hazard control measures are adequate. These include SOP's for maintenance and service operations within enclosed systems and operation procedures for Class 3B and Class 4 laser systems. The procedures should include adequate consideration of safety from non-beam hazards.

LASER CLASSES

Class 1 laser systems are incapable of producing damaging radiation levels during normal operation and are exempt from any control measures. Class 1 laser systems may contain higher class lasers and may produce laser hazards with the exception for embedded lasers if operated with interlocks defeated. Only authorized personnel may operate class 1 laser systems with interlocks defeated.

Class 1M laser systems are incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with optical instruments (telescope).

Class 2 laser systems emit visible light only at a power level of 1 milliwatt or less. The normal aversion response to bright light is adequate protection. Staring into the beam of a class 2 laser is hazardous. However, 2M lasers are potentially hazardous if viewed with optical instruments (telescope).

Class 2M laser systems emit visible light only. The normal aversion response to bright light is adequate protection for unaided viewing.

Class 3R laser systems are potentially hazardous under some viewing conditions. These conditions include viewing directly, specular reflection conditions or if eye is appropriately focused and stable. The probability of an actual injury is small, and the control measures for safe use are straightforward. Most laser pointers fall in this class. Most lasers previously classified as class 3A fall in this category. This laser will not pose a fire or diffuse reflection hazard.

Class 3B laser systems may be eye hazards for direct beam viewing and specular reflections, even for momentary exposures. Class 3B laser reflections are not normally a fire hazard or a laser generated air contaminate (LGAC) production hazard. Class 3B laser systems shall be operated only in laser-controlled areas by authorized operators and are required to be registered with Laser Safety Program. Operators of class 3B laser systems shall receive approved laser safety training. A written Standard Operating Procedures (SOP) for operation, beam alignment, and emergency shut-down is required for class 3B laser operation.

Class 4 laser systems are eye hazards and skin hazards for direct beam exposures, specular reflections, and diffuse reflections. They can also be fire hazards and may produce laser generated air contaminants or hazardous plasma radiation. Class 4 laser systems shall be operated only in laser-controlled areas by authorized operators and are required to be registered with the Laser Safety Program. Operators of class 4 laser systems shall receive approved laser safety training. A written Standard Operating Procedures (SOP) for operation, beam alignment, and emergency shut-down is required for class 4 laser operation.

TRAINING REQUIREMENTS

Laser safety training shall be provided for individuals routinely working with or potentially exposed to Class 3B or Class 4 laser hazards. Training is also required for those laser systems with embedded class 3B or class 4 lasers where beam access by users is required during maintenance or service. Training will be required before an individual works with or around a laser system and every two years after. Principle Investigators are required to provide hands-on specific training for any individual using the laser system. This instruction should include: proper power on, beam alignment, external controls, selection of appropriate eye ware or PPE requirements, etc.

MEDICAL SURVEILLANCE

Baseline eye exams are not required. A medical eye exam is required within 48 hours following a suspected hazardous exposure. Laser personnel shall report any suspected dermal or ocular burns to the Laser Safety Officer immediately or the same day.

If a laser injury is suspected the laser personnel should take the following steps:

Dermal burns:

UT students: seek medical assistance at the UT Student Health Center located at 1800 Volunteer Blvd Knoxville, TN 37996-3102. They can be reached by calling (865) 974-3135. After hours care is arranged through the UT Medical Center Emergency Room located at 1924 Alcoa Highway Knoxville, TN 37920. They can be reached by calling (865) 305-9000.

UT staff and faculty: seek medical assistance at The University of TN Graduate School of Medicine, University Occupational Health Services. More information can be found at http://gsm.utmck.edu/family_medicine/main.cfm and they can be reached by calling (865) 305-8831.

If you are a paid UT employee, complete the UT Risk Management Office “Report of an Occurrence Form” <http://riskmanagement.tennessee.edu/forms.htm> and follow the risk management instructions. UT workman’s compensation procedures may dictate other medical evaluation procedures.

Ocular burns:

All personnel should seek medical assistance from UT Medical Center Emergency Room located at 1924 Alcoa Highway Knoxville, TN 37920. They can also be reached by calling (865) 305-9000. If vision is impaired call 911.

If injured person is a paid UT employee, complete the UT Risk Management Office “Report of an Occurrence Form” <http://riskmanagement.tennessee.edu/forms.htm> and follow the risk management instructions. UT workman’s compensation procedures may dictate other medical evaluation procedures.

USER CONTROL MEASURES

General: User controls are those control measures implemented by the user in addition to the manufacturer control measures to render safe operation, maintenance, and service.

Definitions:

Maximum permissible exposure (MPE). The level of laser radiation to which an unprotected person may be exposed without adverse biological changes in the eye or skin.

Nominal hazard zone (NHZ). The space within which the level of the direct, reflected, or scattered radiation may exceed the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the applicable MPE.

Enclosed Beam Path: In applications of lasers or laser systems where the entire beam path is enclosed and the enclosure fulfills all requirements of a protective housing (i.e., limits exposure to laser radiation to levels at or below the applicable MPE), the requirements of Class 1 are fulfilled and no further controls are required. This is the most desired control method for Class IIIB and IV lasers.

When the protective housing requirements are temporarily relaxed, such as during service, the LSO shall affect the appropriate controls. These may include establishing a temporary laser-controlled area and instituting appropriate administrative controls.

Laser Application (Operation, Maintenance, and Service): The selection and implementation of specific control measures depends on how the laser system is being used. Laser systems are classified on the basis of the level of the laser radiation accessible during intended use (operation). Service and maintenance functions may require access to hazardous laser radiation not accessible during the operation function.

During periods of service or maintenance, control measures appropriate to the class of the embedded laser shall be implemented when the beam enclosures are removed and beam access is possible.

Unsupervised Laser Operations: The unattended use of Class 3B or Class 4 lasers or laser systems shall be permitted only when the LSO has implemented appropriate control measures such as beam traps, barriers, windows, other means of area control, or laser safety training that provide adequate protection to those who may enter the laser-controlled area during times of unattended use.

Laser radiation accessible from unsupervised Class 3B or Class 4 lasers or laser systems shall be limited so that unprotected spectators in the area shall not be exposed to levels that exceed the applicable MPE in any space in the area that they may occupy.

Indoor Laser Controlled Area Minimum Requirements:

The Class 3B and Class 4 laser-controlled area shall:

1. Be controlled to permit lasers and laser systems to be operated only by personnel who have been trained in laser safety and in the operation of the laser or laser systems.
2. Be posted with the appropriate area warning signs. An appropriate area warning shall be posted at the entryway(s) and, if deemed necessary by the LSO, should be posted within the laser-controlled area.
3. Be operated in a manner such that the beam path is well defined.
4. Require the appropriate eye protection for personnel within the laser-controlled area, if the laser beam is not entirely contained.
5. Be under the direct supervision of an individual knowledgeable in laser safety unless laser controls are in place and maintained.
6. Be located so that access to the area by spectators is limited.
7. Have any potentially hazardous beam terminated in a beam stop of an appropriate material.
8. Have only diffusely reflecting materials in or near the beam path, where feasible.
9. Have the laser secured such that the exposed beam path is above or below eye level of a person in any standing or seated position.

10. Have all windows, doorways open portals, etc., from an indoor facility either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the applicable ocular MPE.
11. Require storage or disabling (e.g., removal of the key or password protection) of the laser or laser system when not in use to prevent unauthorized use.

Protective Housings (All Classes): A protective housing shall be provided for all classes of lasers or laser systems. The protective housing may require interlocks and labels. If a user-created laser protective enclosure does not meet the requirements of a protective housing (e.g., a non-interlocked cover), it shall be considered as a barrier or curtain. Other controls or warning labels may be necessary.

Equipment Labeling: All laser equipment shall have appropriate warning labels. The label shall be affixed to a conspicuous place on the laser housing or control panel. Such labels should be placed on both the housing and the control panel.

Key Control (Class 3B or Class 4): Class 3B or Class 4 lasers or laser systems should be provided with a master switch. This master switch shall cause beam termination and/or system shutoff and shall be operated by a key or by a coded access (such as a computer password.)

A single master switch on a main control unit shall be acceptable for multiple laser installations where the operational controls have integrated.

Viewing Windows and Diffuse Display Screens (All Classes): All viewing windows and diffuse (reflective or transmitted) display screens included as an integral part of a laser or laser system shall incorporate a suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation at the viewing position at or below the applicable MPE as determined by the LSO.

Facility Window Protection: Facility windows (exterior or interior) that are located within the NHZ of a Class 3B or Class 4 laser or laser system shall be provided with an appropriate absorbing filter, scattering filter, blocking barrier, or screen that reduces any transmitted laser radiation to levels below the applicable MPE.

Laser Protective Barriers and Curtains: A blocking barrier, screen, or curtain that can block or filter the laser beam at the entryway should be used inside the laser-controlled area to prevent the laser radiation from exiting the area at levels above the applicable MPE.

Beam Paths: Control of the laser beam path shall be accomplished as described in the following:

Fully Enclosed Beam Path: This is often the most desirable configuration. Additional warning devices, PPE, and other controls may be eliminated if the

laser beam remains in an enclosure. A laser hazard evaluation should occur by the LSO prior to operation.

Fully Open and Limited Open Beam Path: In applications of Class 3B or Class 4 lasers or laser systems where a beam path is unenclosed a laser hazard evaluation shall be performed by the LSO prior to operation.

Area Warning Device: A Class 3B laser-controlled area and a Class 4 laser-controlled area shall have an area warning device that is visible prior to entering the area. The purpose of the area warning device is to ensure that persons who are about to enter the laser-controlled area are aware that a laser is emitting or is about to begin emitting accessible laser radiation within the area.

Entryway Controls: All Class 4 laser-controlled areas shall incorporate one of the following alternatives:

- 1. Non-defeatable (non-override) Area or Entryway Safety Controls:** Non-defeatable safety latches, entryway or area interlocks (e.g., electrical switches, pressure sensitive floor mats, infrared, or sonic detectors) shall be used to deactivate the laser or reduce the output to levels at or below the applicable MPE in the event of unexpected entry into the laser-controlled area.
- 2. Defeatable Area or Entryway Safety Controls:** Defeatable safety latches, entryway, or area interlocks shall be used if non-defeatable area/entryway safety controls limit the intended use of the laser or laser system. If it is clearly evident that there is no laser radiation hazard at the point of entry, override of the safety controls shall be permitted to allow access to authorized personnel provided that they have been adequately trained and provided with adequate personal protective equipment.
- 3. Procedural Area or Entryway Safety Controls:** Where safety latches or interlocks are not feasible or are inappropriate the following shall apply:
 - a) All authorized personnel shall be adequately trained and adequate personal protective equipment shall be provided upon entry.
 - b) A door, blocking barrier, screen, curtains, etc., shall be used to block, screen, or attenuate the laser radiation at the entryway.
 - c) At the entryway there shall be an area warning device indicating that the laser is energized and operating at Class 4 levels.

Authorized Personnel: Class 3B or Class 4 lasers or laser systems shall be operated, maintained, or serviced only by authorized personnel.

Engineering Controls: All laser products that are sold, imported or otherwise distributed to users must comply with the Federal Laser Product Performance Standard (FLPPS). Laser products that are sold as component or component subsystems or repair parts to, by or for manufacturers of certified laser products are not required to comply with the FLPPS.

A laser or laser system may be developed or modified by a user for internal use only. User-developed or user-modified laser products shall have their engineering controls reviewed and approved by the LSO to determine the adequacy of their protection.

Laser Demonstrations: Laser demonstrations involving the general public (including students) must be supervised and should be Class 1, Class 1M, Class 2, Class 2M, or Class 3R. Class 3B and Class 4 public demonstrations should be avoided. Contact the LSO for hazard assessment if Class 3B or 4 systems are to be used.

Outdoor Control Measures (All Classes): All lasers or laser systems used outdoors shall meet the requirements found in ANSI Z136.6.

ALIGNMENT PROCEDURES

Laser incident reports have repeatedly shown that ocular injuries can be a risk during beam alignment procedures.

Alignment of Class 3B or Class 4 laser optical systems (e.g., mirrors, lenses, beam deflectors) shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of a beam, does not expose the eye to a level above the applicable MPE.

Written SOPs outlining alignment methods should be approved by the LSO for Class 3B and shall be approved for Class 4 lasers or laser systems.

The use of lower power (Class 1, Class 2 or Class 3R) visible lasers for path simulation of higher power lasers is recommended for alignment of higher power Class 3B or Class 4 visible or invisible laser and laser systems.

Alignments should be performed only by those who have received laser safety training. A Class 3B or Class 4 laser-controlled area (LCA) shall be established. In addition, the following actions should be taken:

1. Exclude unnecessary personnel from the laser-controlled area during alignment.
2. Whenever possible, use low-power visible lasers for path simulation of higher-power visible or invisible lasers.
3. Wear laser eye protection and protective clothing to the extent practicable.
4. When aligning invisible (and in some cases visible) laser beams, use beam display devices such as image converter viewers or phosphor cards to locate beams.
5. Perform alignment tasks that use high-power lasers at the lowest possible power level.
6. Use a shutter or beam block to block high-power beams at their source except when actually needed during the alignment process.
7. Use a laser-rated beam block to terminate high-power beams down range of the optics being aligned.

8. Use beam blocks and/or laser protective barriers in conditions where alignment beams could stray into areas with uninvolved personnel.
9. Place beam blocks behind optics (e.g., turning mirrors) to terminate beams that might miss mirrors during alignment.
10. Locate and block all stray reflections before proceeding to the next optical component or section.
11. Be sure all beams and reflections are properly terminated before high-power operation.
12. Post appropriate area warning signs during alignment procedures where lasers are normally Class 1 (enclosed).

PERSONAL PROTECTIVE EQUIPMENT

General: Enclosure of the laser equipment or beam path is the preferred method of control since the enclosure will isolate or minimize the hazard. When other control measures are not practicable, personal protective equipment (PPE) shall be used to provide protection against laser radiation.

EYEWEAR POLICY

Eye Protection: Eye protection devices that are specifically designed for protection against radiation from Class 3B and Class 4 lasers or laser systems shall be required within the NHZ (Nominal Hazard Zone) and their use enforced when engineering or procedural and administrative controls are not practicable.

For all routine laser operations and for most laser alignment procedures, the laser eye protection used shall provide full protection against a possible direct beam or specular reflection exposure. Use of alignment eyewear shall only be for specific alignment procedures with visible laser beams that have been appropriately evaluated and authorized. All laser protective eyewear shall be clearly labeled with the OD (Ocular Density) and wavelength for which protection is afforded.

Periodic cleaning and inspection shall be performed on laser eye protection to ensure they are maintained to a satisfactory condition. The frequency of the safety inspection should be once per year, or as determined by the LSO.

Engineering control measures shall be implemented with high-power, multi-kilowatt laser beams, high frequency pulsed lasers and potentially dual energy lasers. If such control measures are impractical, administrative control measures may be used. PPE, in the form of laser eye protection, may be inadequate to protect the user from serious ocular exposure from such laser beams. In these cases, additional enclosures of the laser beam may be necessary.

SKIN PROTECTION

Skin protection can best be achieved through engineering controls. In some cases, a laboratory jacket or coat may fulfill the requirement, although tightly-woven, flame retardant fabrics provide the best protection for Class 4 lasers.

Particular care should be taken when using UV lasers or laser systems. Exposure to UV radiation shall be minimized by using beam shields and clothing that attenuate the radiation to levels below the applicable MPE for specific UV wavelengths. Please consult the LSO for assistance in preventing UV skin burns.

SPECIAL CONSIDERATIONS

Laser use involving the general public: Laser systems involving the general public or class demonstrations should be limited to Class 1, 1M, 2, 2M or Class 3R. Class 3B and Class 4 public demonstrations should be avoided.

Laser Optical Fiber Systems: Laser systems that employ optical fiber cables that contain all hazardous laser radiation shall be considered enclosed systems with the optical cable forming part of the enclosure.

Cable Disconnection: If disconnection of a connector results in an accessible laser radiation above the MPE, disconnection shall take place only in an appropriate temporary laser-controlled area.

Laser Pointers: Laser pointers shall not exceed Class 3R. Laser pointers that are Class 3B can cause eye damage if the beam is viewed directly.

LASER SAFETY COMMITTEE

The University of Tennessee, Knoxville has a Laser Safety Committee who provide guidance in the establish and maintain adequate policies and practices for the evaluation and control of laser hazards, including training materials.

OTHER PERSONNEL RESPONSIBILITIES

Laser Supervisor: The supervisor of individuals working with or having the potential for exposure to greater than Class 1 laser radiation should have basic overall knowledge of laser safety requirements for the lasers under the supervisor's authority.

The following responsibilities should be considered as a minimal set of responsibilities for the Laser Supervisor:

1. The supervisor shall be responsible for the issuance of appropriate instructions and training materials on laser hazards and their control to all personnel who may work with lasers that are operated within the supervisor's jurisdiction.
2. The supervisor shall not permit the operation of a laser unless there is adequate control of laser hazards to employees, visitors, and the general public.
3. The supervisor shall submit the names of individuals scheduled to work with lasers to the Laser Safety Program and shall submit information as requested by the LSO for training completion.
4. When the supervisor knows of, or suspects, an accident resulting from a laser operated under his or her authority, the supervisor shall immediately upon becoming aware of a suspected laser incident implement the institution's accident response plan and ensure it includes notification of the LSO.
5. If necessary, the supervisor shall assist in obtaining appropriate medical attention for any employed involved in a laser accident.
6. The supervisor shall not permit operation of a new or modified Class 3B or Class 4 laser under his or her authority without the approval of the LSO.
7. The supervisor shall submit plans for Class 3B and Class 4 laser installations or modifications of installations to the LSO for review.
8. For Class 3B or Class 4 lasers and laser systems, the supervisor shall be familiar with the SOPs and ensure that they are provided to users of such lasers.

Responsibility of Employees Working with Lasers: Employees working with lasers or laser systems shall have, where applicable, the following minimal responsibilities:

1. An employee shall not energize or work with or near a laser unless authorized to do so by the supervisor for that laser.
2. An employee shall comply with safety rules and procedures and PPE prescribed by the supervisor and the LSO. The employee shall be familiar with all applicable operating procedures.
3. When an employee operating a laser knows or suspects that an accident has occurred involving that laser, or a laser operated by any other employee, and that such accident has caused an injury or could potentially have caused an injury, he or she shall immediately inform the supervisor. If the supervisor is not available, the employee shall notify the LSO.

Other Personnel: Anyone involved in purchasing a laser or laser system should contact the LSO. Such personnel may also include, but not be limited to, purchasing, accounting, and building management, as may be applicable.

AUDITS

An audit and inspection of Class 3B and Class 4 lasers shall be conducted at least once every two years. The Laser Safety Program shall be audited periodically.

RECORDS

The LSO shall ensure that the necessary records which document the Laser Safety Program are maintained. These records shall include:

- Training records
- Standard Operating Procedures for all class 4 lasers
- Laser system inspection
- Laser safety audit reports
- Registration records and approvals
- Records of any accident or injury
- Hazard evaluations

Appendix 1:

Requirements for Embedded Class 3B and Class 4 Lasers during Maintenance

Training:

Training is required for any operator, maintenance, or service personnel of a laser system with embedded class 3B or class 4 lasers where beam access by users is required during maintenance or service.

Standard Operating Procedures:

SOPs for maintenance and service as specified in the laser manufacturer's manual shall be provided by the laser system operator.

Protective Housing Interlock Requirements:

Protective housings that enclose class 3B or class 4 lasers or laser systems shall be provided with an interlock system that is activated when the protective housing is opened or removed during operation or maintenance. The interlock or interlock system shall be designed to prevent access to laser radiation above the applicable MPE. The interlocks are typically electrically connected to a beam shutter. The removal of the panel closes the shutter and eliminates the possibility of hazardous exposures.

Fail-safe or redundant interlocks shall be provided for any portion of the protective housing that, by design, can be removed or displaced during maintenance and thereby allow access to class 3b and class 4 laser radiation.

Service Access Panels:

The ANSI Z136.1 standard requires that any portion of the protective housing that permits direct access to an embedded class 3B or class 4 lasers (intended for removal only by service personnel) must have either an interlock or require a tool in the removal process. If the interlock can be bypassed or defeated, a warning label indicating this fact is required on the housing near the interlock. The design shall not allow replacement of a removed panel with the interlock in the defeated position.

Eye and Skin Protection:

Eye protection appropriate for the wavelength of the laser for all maintenance workers is required.

The requirements for skin protection should be as indicated by the laser manufacturer, as specified in their laser safety information.

During Times of Service:

According to ANSI Z136.1, *NOTICE* signs are required for class 3B and class 4 lasers during maintenance, servicing and similar situations. This sign is posted only during the time when service is in progress. Please contact the Radiation Safety Office during times of service by emailing radiationsafety@utk.edu or by calling our office @ (865) 974-5580.