LASER SAFETY MANUAL

DEPARTMENT OF ENVIRONMENTAL HEALTH AND SAFETY

RADIATION SAFETY OFFICE

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INTRODUCTION

This manual was written for the research and clinical areas at the University of Louisville utilizing lasers will operate them safely, minimizing the risks associated with their use. To achieve this goal, the University has adopted the American National Standard for Safe Use of Lasers, ANSI Z 136. This standard is recognized as a minimum standard for laser safety. Additionally, the program is designed to ensure that adequate protection against collateral hazards is provided. These collateral hazards include the risk of electrical shock, fire hazard from a beam or from use of dyes and solvents, chemical exposures from use of chemicals and vaporization of targets, and the emission of ionizing and non-ionizing radiation from power supplies associated with the operation of the laser or laser system.

All class 3B and Class 4 lasers operations at the University of Louisville shall be registered with the Radiation Safety Office. The RSO or designee will conduct a laser hazard assessment and it will be the responsibility of the Laser Supervisor (LS) to correct any safety deficiencies identified in the hazard assessment.

This manual shall be available for reference by all Laser Users (LU) at the University of Louisville. It is available on the U of L website of the Department of Environmental Health and Safety Office. All uses and supervisors shall be familiar and comply with the requirements of this manual.

Exceptions to the ANSI standard will be considered on a case-by-case basis by the Radiation Safety Office; the RSO shall document and keep record of any policy decisions that are exceptions to the ANSI standard.

If you need additional information or assistance, contact the Radiation Safety Office at 852-5231.

ACRONYMS/ABBREVIATIONS

ANSI – American National Standards Institute
CW – Continuous Wave laser
EHS – Environmental Health & Safety
LS – Laser Supervisor
LSC – Laser Safety Committee
LSO – Laser Safety Officer
LU – Laser User
MPE – Maximum Permissible Exposure
NHZ – Nominal Hazard Zone
OD – Optical Density
RSO – Radiation Safety Office
SOP – Standard Operating Procedure
U of L – University of Louisville

CONTROL MEASURES

Control measures for Class 3B and 4 lasers area designed to reduce the possibility of eye and skin exposure to laser radiation in excess of the applicable Maximum Permissible Exposure (MPE) limit and other hazards associated with the laser systems.

The MPE is the maximum safe exposure without hazardous effect or adverse biological changes in the eye or skin. The MPE depends upon the wavelength and exposure duration. The MPE is not affected by physical changes in the laser experiment layout. The Nominal Hazard Zone (NHZ) is the distance at which laser exposure may exceed the MPE. For a given laser, changes in the laser power level, beam diameter, mean divergence and the MPE will affect the NHZ.

Control measures area engineering, administrative and procedural controls, and personal protective equipment. Engineering controls are always the preferred method to provide for safety in a laser laboratory. Administrative and procedural controls and personal protective equipment are to be used only where the engineering controls are inadequate or impractical to prevent access to laser radiation that may be or is in excess of the MPE. It is common that all types of control measures are required for a given laser system.

An important consideration when implementing control measures is to distinguish between operation, maintenance, and service. Control measures are to be based on the normal operation of the laser system. When either maintenance or service is performed, it is often necessary to implement control measures that are not needed under normal operation. This specifically applies to the maintenance or service of laser systems that are classified less than Class 3B for normal operation, but contain embedded Class 3B or 4 lasers.

ORGANIZATION OF THE LASER SAFETY PROGRAM

RESPONSIBILITIES

Laser Users (LU):

1. Laser Users (LU) are individuals that have completed the laser safety training, and uses/maintains/services Class 3B or 4 lasers under the direction of a Laser Supervisor (LS). An employee or student shall not operate a Class 3B or 4 laser system unless authorized to do so by the LS. The LU must comply with the following:
    a. Be familiar with the standard operating procedures (SOPs) of the laser system you are using, including interlocks, beam stops and other engineering and administrative safety controls.
    b. Attend Laser Safety Training.
    c. Notify the Laser Supervisor of any departure from the SOPs.
    d. Notify the Laser Supervisor and the RSO in the event of an exposure incident. HOWEVER, THE TREATMENT OF THE INJURED PERSONNEL AND THE PRESERVATION OF PROPERTY SHALL BE THE FIRST PRIORITY.

Laser Supervisor (LS):

1. An LS is a faculty or staff member that has primary responsibility for any use/maintenance/service of a given Class 3B or 4 laser. The LS shall notify the LSO of any Class 3B or 4 laser acquisition prior to placing the order or otherwise arranging for its receipt (i.e. donation, loans, etc.) The LS shall know the training requirements, the potential laser hazards and associated control measures, and all SOP's pertaining to the laser safety for lasers and laser systems under the LS's control. **The LS shall contact the RSO when a laser is being used under their supervision.** The LS must comply with the following:
    i. Supervising the use of lasers in the laboratory.
    ii. Shall determine which students and employees are authorized to operate a laser system under their control.
    iii. Be familiar with the safe operating practices of the laser system you are using and **have standard operating procedures (SOPs) available**. Prevent the operation of a laser if exposure to anyone could exceed the MPE.
    iv. Provide laser operators with instruction on operating, administrative, and alignment procedures for the laser.
    v. Ensure all lasers in the lab are properly classified and labeled and the proper signs are posted as required.
    vi. Emergency procedures shall be posted in each laser facility.
    vii. Notify the Radiation Safety Office immediately in the event of an exposure incident. The LS shall assist in obtaining appropriate medical attention for any employee or student involved in the laser accident. A written incident

report shall be prepared by the LS and given to the RSO as soon as possible after the accident.

viii. Provide personal protective equipment to Laser Operators, such as eyewear.

Radiation Safety Office (Laser Safety Officer)

1. The Radiation Safety Office will work with the individual LS to ensure the safety standards of each laser laboratory are adequate. The RSO has the authority to monitor and enforce the control of laser hazards at U of L. An inventory will be kept of all lasers utilized at the University. The RSO shall comply with the following:
   a. Provide Laser Safety Training to each employee and student routinely operating a Class 3B or 4 laser or laser system.
   b. All Class 3B and 4 lasers must be inventoried with the RSO; the RSO shall periodically contact the LS to ensure the laser inventory is current.
   c. The RSO will ensure that all appropriate records regarding laser safety are maintained and that an SOP is available in the area where the laser is used.
   d. The RSO shall perform audits of the areas where lasers are used. The audit will include, but not be limited to: signage, housing of the laser, records or training, location of SOP, availability of PPE, and the inventory.
      i. The RSO will ensure corrective action is taken where required if any audit indicated the need.
   e. Upon notification of a known or suspected laser-related accident or injury, the RSO shall investigate the incident and take appropriate action. The RSO shall perform a hazard evaluation of the laser facility to determine the cause of the accident, interview individuals involved in the accident, and make certain that necessary controls have been implemented before operation resumes. The RSO has the authority to suspend operations until a full investigation has been completed.

REGISTRATION OF LASERS

An inventory of all Class 3, 3B, and 4 lasers must be kept on file at the Radiation Safety Office. When purchasing or acquiring a laser, complete the Laser Registration Form and submit a copy of the completed form to the Radiation Safety Office. This form must be completed for any Class 3B or 4 lasers, or any lower class system containing an embedded Class 3B or 4 laser. Upon receiving this form, the Radiation Safety Office will perform an inspection of the laser in the facility.

A signed copy of the Laser Supervisor Responsibilities shall be signed and submitted to the Radiation Safety Office along with the Registration Form. This form indicates that the supervisor acknowledges the responsibilities of the lab utilizing lasers in their work.

1. Laser Supervisor Information:			
Name:			
Department:		E-mail:	
2. Laser Location:			
Building:		Room:	

3. Type of Use:

□ Alignment	□ Experimental	□ Research
□ Demonstration	□ Instructional	□Other

4. Brief Description of Use (including how often used):

Laser Status: □ In Use □ In Storage	Manufacture Date:
Manufacturer:	Model:
S/N:	Active Medium:
Class: □ 3B □ 4	Embedded in lower class system? □ Yes □No
Tunable Laser? □ Yes □No	□ Scanning □ Nonscanning
Beam Diameter (mm):	Beam Divergence (mradian):
Beam diameter & Divergence measured at the □ 1/e □ $1/e^2$ point.	

□ Continuous Wave (CW)	Pulsed: (□ Single □Multiple)
Wavelength(s) (nm):	Wavelength(s) (nm):
Maximum Operating Power:	Minimum Pulse Duration:
Typical Operating Power:	Maximum Pulse Frequency:
	Maximum Joules/Pulse:
	Typical Joules/Pulse:

I certify that the information contained in this form is true and correct to the best of my knowledge and belief:

Laser Supervisor Signature:_____ Date:_____

TO BE COMPLETED BY THE LASER SUPERVISOR REGISTRANT

LASER SUPERVISOR RESPONSIBILITIES

1. I understand that as a Laser Supervisor I shall provide direct supervision of all Laser Users under my supervision during laser use until such time as I or my authorized designee are confident that they can handle the equipment safely and competently.

2. I understand that as a Laser Supervisor I shall provide training specific to the protocols in my lab.

3. I understand that as a Laser Supervisor I shall designate in writing to the Radiation Safety Office an alternate Laser Supervisor to provide oversight of my laser labs during a leave of absence greater than 60 days.

4. I understand that as a Laser Supervisor I shall notify the Radiation Safety Office in writing of my intention to terminate my Laser Supervisor status at least 30 days prior to the proposed termination.

5. I understand that as a Laser Supervisor I shall notify the Radiation Safety Office in writing of my intention to move my laser/laser lab at least 30 days prior to the proposed move.

6. I understand that as a Laser Supervisor I shall be responsibility for all lasers on my inventory and I shall complete and sing my Annual Laser Inventory within two weeks of receiving the inventory.

7. I understand that as a Laser Supervisor I or my authorized designee shall review for correctness and sign all forms documenting requests for the acquisition, use or disposal of lasers in my lab(s).

8. I have read and understand the University of Louisville Laser Safety Policy Manual. I agree to adhere to this policy and assume responsibility for the safe use of lasers.

9. I certify that the statements contained in this application are correct and comlete to the best of my knowledge and belief.

Laser Supervisor Registrant Signature:_____

Laser Supervisor Printed Name:_____

Date:_____

PERSONNEL TRAINING AND QUALIFICATIONS

All Laser Supervisors and Laser Users must be trained in the safe use of lasers prior to beginning laser work. Laser Safety Training is offered by the Radiation Safety Office via an online program.

The training will include at least the following topics:

A. Fundamentals of laser operation
B. Bioeffects of laser radiation on the eye and skin
C. Significance of specular and diffuse reflections
D. Non-beam hazards of lasers
E. Control measures
F. Overall responsibilities of management and employees
G. Medical surveillance practices (if applicable)

Everyone operating the laser shall review the Laser Safety Manual. All laser operators shall receive instructions from the Laboratory Supervisor on the safe operation of the laser, administrative procedures, alignment procedures and other applicable SOPs.

A link to the laser safety training can be found at the U of L DEHS website:

https://louisville.edu/dehs/train

POTENTIAL LASER HAZARDS

All accidents involving lasers must be reported to the LS and Radiation Safety Office immediately. This includes chemical exposures, laser generated air contaminants, electrical shock accidents, as well as eye and skin injuries.

Medical examinations shall be performed as soon as practical (usually within 48 hours) when a suspected injury or adverse effect from a laser exposure occurs. In addition to the acute symptoms, consideration shall be given to the exposure wavelength, emission characteristics and exposure situation to assure appropriate medical referral. ANSI Z136 provides recommended examination protocols by observed symptoms and the type of laser.

All proper procedures must be used when utilizing lasers. Personal protective equipment must be available and worn when working with lasers where it is required. Many injuries are caused by not utilizing the proper equipment and failure to follow Standard Operating Procedures (SOPS).

Types of injuries caused by lasers are:

A. Eye Injury

It is the high degree of coherence of the light beam from a laser that makes it an ideal tool for research and clinical applications. However, this coherence of the beam also makes the light (direct beam and reflected light) a serious threat for damage to the human eye. A laser beam of sufficient power has the potential to produce retinal intensities orders of magnitude greater than conventional light sources. Laser light has the potential to be more damaging the human eye than direct viewing of the sun. Permanent blindness can be the result.

B. Thermal Injury

The most common cause of laser induced tissue damage is thermal in nature. Tissue proteins can be denatured due to the temperature rise following absorption of laser energy. The thermal injury process (burns) associated with lasers is most prevalent for exposure times greater than 10 microseconds with wavelengths in the near ultraviolet and far infrared. In addition, tissue damage can be caused by thermally induced acoustic waves (phonons) following sub microsecond laser exposures. Continuous wave lasers have the
potential to do more damage to tissue because of their higher average power. However, pulsed or scanning lasers can produce effects that are additive if they are being absorbed in the same volume of tissue. The principal thermal effects of laser exposure depends on the absorption and scattering coefficients of the tissue, irradiance of the laser beam, duration of
the exposure and pulse repetition rates, extent of the local vascular flow in the affected tissue, and area of the irradiated tissue.

C. Other Damage Mechanisms

Photochemical reactions are possible for ultraviolet exposures. Even “blue” light exposures greater than 10 seconds can lead to photo-chemical reactions in tissue. In addition Ultraviolet A (UVA) can cause hyperpigmentation and erythema in skin. Ultraviolet B (UVB) has the possibility to cause radiation carcinogenesis (ie skin cancer). Lasers contain high voltage power supplies that can lead to serious injury or death from electrocution. This is can occur even if the laser has been turned off, as capacitors in the high voltage supply can store potentially lethal current for hours or even days.

1. **Eye**

   Bio-effects of the eye are summarized in the following table:

SPECTRUM	LOCATION	EFFECT
UV-C (200-280 nm)	Cornea	Photokeratitis
UV-B (280-315 nm)	Cornea	Photokeratitis
UV-A (315-400 nm)	Lens	Cataract
Visible (400-780 nm)	Retina	Retinal injury*
IR-A (780-1400 nm)	Retina, Lens	Retinal burn, cataract
IR-B (1400-3000 nm)	Cornea, Lens	Corneal burn, cataract
IR-C (3000-1000000 nm)	Cornea	Corneal burn
* Retinal injury can be thermal, acoustic or photochemical.		

2. **Skin**

   Bio-effects of the skin are summarized in the following table:

SPECTRUM	LOCATION
UV-C (200-280 nm)	Erythema, cancer, accelerated aging
UV-B (280-315 nm)	Erythema, increased pigmentation, cancer, accelerated aging
UV-A (315-400 nm)	Erythema, increased pigmentation, skin burn
Visible (400-780 nm)	Photosensitive reactions, skin burn
IR-A (780-1400 nm)	Skin burn
IR-B (1400-3000 nm)	Skin burn
IR-C (3000-1000000 nm)	Skin burn

DISCONTINUATION OF USE OR DISPOSAL OF LASER SYSTEM

The Radiation Safety Office must be notified when there is a permanent discontinuation of laser operation or the permanent disposal of a laser system.

Radiation Safety Office – 852-5231

Email Sarah Hughes – sarah.hughes@louisville.edu

LASER STANDARD OPERATING PROCEDURE

Laser Standard Operating Procedure (SOP) Template

Instructions:

 Use this template to create a standard operating procedure for each Class 3B or Class 4 lasers.

***NOTE**: If your SOP(s) is already documented in another form and it includes the information indicated in this template, you may use your current document(s).*

 The Laser Supervisor shall train all Laser Users on this procedure and ensure it is followed each time the laser is used.

 Keep this SOP in a common location readily available to the Laser Supervisor and Laser User.

 This SOP should always be available for review upon request of the Laser Safety Officer.

 For specifications or operating conditions that frequently change, list anticipated ranges of specifications or operational settings.

LASER STANDARD OPERATING PROCEDURE

This Laser Standard Operating Procedure has been written to aid with the safe use of the laser identified below. Laser Supervisors and Laser Users must follow this procedure for each laser use.

LASER SAFETY CONTACTS:

LASER SUPERVISOR:		**Phone:**		**Mobile:**	
PRIMARY LASER USER:		**Phone:**		**Mobile:**	
RADIATION SAFETY OFFICE:	**Sarah Hughes/ Patrick Glisson**	**Phone:**	**852-5231**		
Medical Emergencies and Fire:	**Louisville Metro Police Department (LMPD)**		**PHONE:**	**911**	
NOTE: *If 911 is dialed from a U of L phone, you will get LMPD emergency and they will contact UL DPS automatically. If you call from a cell phone, you need to know the address where you are located.*					

1. LASER DESCRIPTION

Laser Type:		Laser Location:	
Manufacturer:		Department:	
Model:		Building:	
Class:	☐ 3B ☐ 4	Room Number:	

Emission	Wavelength or Wavelength Range (nm)	Power (W)	Pulse Energy (J)	Pulse Duration (sec)	Pulse Frequency (Hz)	Eyewear Optical Density Required
☐ CW ☐ Pulsed						

Brief Description of Laser Use:

LASER STANDARD OPERATING PROCEDURE

2. LASER SAFETY PROGRAM

Please refer to the University of Louisville Laser Safety Policy Manual at http://www.louisville.edu/dehs for the responsibilities of the Laser Supervisor and Laser User, a basic description of hazard control measure, warning sign requirements, laser safety training, and laser registration.

3. SETUP, ALIGNMENT AND OPERATING PROCEDURES

a. Alignment/Setup
(Include specific beam alignment/visualization aids to be used as well as PPE)

b. Start-up and Operation
(list the basic sequential events that describe the complete operation, including when to don laser eyewear, etc. The procedures shall be written for the benefit of the Laser User who must read and understand them to perform the operation safety.)

c. Shutdown
(describe normal and emergency shutdown procedures)

LASER HAZARD CONTROL MEASURES		
Check if applicable	**Control**	**Comments**
☐	Entryway (door) interlocks	
☐	Laser protective housing interlocks	
☐	Emergency stop/panic button	
☐	Master switch (operated by key or computer password)	
☐	Beam stops/attenuators	
☐	Beam path enclosure (e.g. light, pipe)	
☐	Protective barriers	
☐	Warning signs	
☐	Warning lights	
☐	Other (specify):	

4. PERSONAL PROTECTIVE EQUIPMENT

Laser Protective Eyewear

WEAR THIS EYEWEAR:		
EYEWEAR MANUFACTURER	**PROTECTED WAVELENGTHS (s)**	**OPTICAL DENSITY (OD)**

Other Protective Equipment

Describe other protective equipment used. This might include the use of lab coats and/or sunscreen for UV laser use. Other items to describe here include laser rated barriers, curtains, window filters, etc.

5. NON-BEAM HAZARDS OF THIS SYSTEM (CHECK ALL THAT APPLY)

Check all non-beam hazards that apply and provide a brief description of the control measure(s) implemented to control the hazard.

☐ Chemical (dyes, solvents, etc.): attach applicable MSDS sheet

☐ Electrical (high voltage, large current, capacitors, etc.)

☐ Laser Generated Air Contaminants

☐ Compressed gases or cryogenic liquids

☐ Fire/ignition source

☐ Plasma/blue light exposure

☐ Other (specify):

LASER STANDARD OPERATING PROCEDURE

EMERGENCY PROCEDURES

In Case of Emergency

1. Shut down laser (if it is safe to do so)

2. If there is a fire or medical emergency, call 911

3. For non-emergency injuries:

   a. Go to the nearest Campus Health Services Office at HSC or Belknap for treatment during normal business hours.
   b. SUPERVISOR: Call ahead to the Health Services Office (852-6446) to notify staff and complete the Injury/Illness forms available.

Report work-related injuries or illnesses immediately, no matter how insignificant the incident may seem. Contact DEHS, at 852-6670, to report an injury.

4. Contact the Laser Supervisor and Radiation Safety Office immediately.

LASER SAFETY CONTACTS:

LASER SUPERVISOR:		**Phone:**		**Mobile:**	
PRIMARY LASER USER:		**Phone:**		**Mobile:**	
RADIATION SAFETY OFFICE:	**Sarah Hughes/ Patrick Glisson**	**Phone:**	**852-5231**		
Medical Emergencies and Fire:	**Louisville Metro Police Department (LMPD)**		**PHONE:**	**911**	
NOTE: *If 911 is dialed from a U of L phone, you will get LMPD emergency and they will contact UL DPS automatically. If you call from a cell phone, you need to know the address where you are located.*					

TYPICAL LASER CLASSIFICATIONS

A. Class 1 Lasers

1. Engineering Controls

   A protective housing shall be provided. If the laser consists of an enclosed class 3b or 4 laser, interlocks shall be provided on any removable part of the protective enclosure, or the laser shall have a service access panel that is interlocked or requires a special tool to access.

2. Administrative Controls

   If the unit is a class 3b or 4 laser and Maximum Permissible Exposure(MPE) limits could be exceeded while servicing the unit, the service personnel shall comply with control measures appropriate for the class of the enclosed laser. If during service the MPE could be exceeded, a temporary laser control area must be established.

B. Class 2 Lasers

1. Engineering Controls

   A protective housing shall be provided. Appropriate warning labels shall be posted. Viewing ports and display screens must be designed to prevent exposures from exceeding the MPE. If the enclosed laser is class 3b or 4, interlocks must be provided, or service access panels must be interlocked, or require a special tool to remove.

2. Administrative Controls

   If the enclosed laser is class 3b or 4, and the MPE can be exceeded, service personnel shall comply with control measures, including protective eye wear appropriate for class 3b or 4 lasers. If during service the MPE could be exceeded, a temporary laser control area must be established.

C. Class 2a Lasers

1. Engineering Controls

   A protective housing shall be provided. Appropriate warning labels shall be conspicuous. If the enclosed laser is a class 3a or 4 laser, interlock shall be provided on removable parts of the housing or a special tool required to open a panel.

2. Administrative Controls

   If the enclosed case is a class 3b or 4 laser and Maximum Permissible Exposure (MPE) limits could be exceeded while servicing the unit, service personnel shall comply with control measures appropriate for the class of the enclosed laser. If during service the MPE could be exceeded, a temporary laser control area must be established.

D. Class 3a Lasers

1. Engineering controls

   A protective housing shall be provided. Warning labels must be conspicuous. If the enclosed laser is class 3b or 4, interlocks must be provided, or service access panels must be interlocked, or require a special tool to remove.

2. Administrative Controls

   If the enclosed laser is class 3b or 4, and MPE can be exceeded, service personnel shall comply with control measures, including protective eye wear appropriate for class 3b or 4 lasers. Alignment procedures shall insure that MPE's are not exceeded. If during service the MEP could be exceeded, a temporary laser control area must be established.

E. Class 3b Lasers

1. Engineering controls

   A protective housing shall be provided. The area must be denoted with conspicuous warning signs. Permanent beam stops or attenuators must be provided and cannot be removed or altered. Viewing ports and display screens must be designed to prevent exposures from exceeding the MPE. Interlocks must be provided, or service access panels must be interlocked, or

require a special tool to remove. A key controlled master "on" switch should be provided. An alarm or warning light should be activated during start up and prior to producing the laser beam output.

2. Administrative Controls

A controlled area with conspicuous warning signs must be established to limit access to the public. All individuals in the controlled area must have appropriate eye protection. Use of class 3b lasers out of doors is prohibited without express written permission of the Department of Environmental Health and Safety. Education and training shall be given to laser users. The beam must be terminated into a beam stop whenever possible. The laser must be disabled when not in use.

F. Class 4 Lasers

1. Engineering Controls

A protective housing shall be provided. The area must be denoted with conspicuous warning signs. Permanent beam stops or attenuators must be provided and cannot be removed or altered. Viewing ports and display screens must be designed to prevent exposures from exceeding the MPE. Interlocks must be provided, or service access panels must be interlocked, or require a special tool to remove. A key controlled master "on" switch should be provided. An alarm or warning light should be activated during start up and prior to producing the laser beam output.

2. Administrative Controls

A controlled area with conspicuous warning signs must be established to limit access to the public. All individuals in the controlled area must have appropriate eye protection. Use of class 4 lasers out of doors is prohibited without express written permission of the Department of Environmental Health and Safety. Education and training shall be given to laser users. The beam must be terminated into a beam stop whenever possible. The laser must be disabled when not in use.

Embedded Class 3B or 4 Lasers

University of Louisville has a number of laser systems in use that are Clas1 lasers for normal operation. Many of these Class 1 lasers, such as laser engravers and sereo lithography systems actually contain an embedded Class 3B or 4 laser. During activities outside of normal operation, such as maintenance, repair, or other servicing, exposure to laser radiation above the MPE is possible.

As such, laser hazard control measures that are not required for normal operation will be required during these activities. The control measures may include, but not necessarily be limited to:

- Entryway warning signs
- Temporary use of laser barriers
- Use of laser protective eyewear
- Laser safety training for individuals doing maintenance, repair, etc.

Contact the Radiation Safety Office for assistance.

CLASS 3B AND CLASS 4 LASER REQUIREMENTS SUMMARY

This provides the Laser Supervisor a summary of the steps required for documenting the possession and use of Class 3B and Class 4 lasers and laser systems. It also serves as a summary of the proper control measures for preventing eye or skin exposure in excess of the applicable Maximum Permissible Exposure (MPE) limit. The application of control measures will be specific to each laser setup and will be determined based on a laser hazard analysis.

Laser User Registration and Laser Registration

- Complete Form "Laser User Registration" and "Laser Registration" and submit to the Radiation Safety Office [Required].
- Notify the Radiation Safety Office of planned acquisition prior to laser purchase (by e-mail is fine); indicate vendor, laser type, wavelength(s), maximum power and planned use location [Required].

Laser Safety Training

- Complete laser safety training [Required].
- Ensure Laser Users you supervise complete laser safety training prior to operating a laser [Required].
- Provide your Laser Users with operational training for each laser they will use under your supervision [Required].

Control Measures

The control measures listed in the following pages contain the ANSI Z136 section reference (in brackets) and an indication of whether the measure is a recommendation or a requirement. There may be some instances in which we have chosen to adopt an ANSI recommendation as a requirement.

General

1. Maintain beam height at a level other than the normal position of the eye of a person standing or sitting [Recommended 3B and 4]
2. Class 3B and 4 lasers shall be operated at all times under the direct supervision or control of an experienced, trained Laser User or Laser Supervisor. This supervision shall afford visual access to the entire laser controlled area during all conditions of operations so that laser emission can be terminated in the event of equipment malfunction or any other condition of unsafe use. [Required 3B and 4]
3. Unattended laser operation is allowed only when control measures are in place to provide adequate protection and laser safety training to those who may enter the laser controlled area during times of unattended use. The area laser warning signs in place must include instructions regarding the hazards of entry into the space when no operator is present. [Required 3B and 4]

Engineering Controls

Protective Housings

1. A protective housing shall be present and in good condition [Required 3B and 4]
2. If the protective housing is user-created, appropriate control measures shall be instituted. [Required]

Service Access Panels

1. Any service panel intended only for removal by service personnel shall be interlocked or removable only with special tool. A laser warning label shall be included on the service panel if it is removable with a special tool. [Required 3B and 4]

Master Switches

1. The laser should have a master switch for beam termination or system shutoff that is either key operated or computer password accessible. [Recommended 3B and 4]

Viewing Windows, Display Screens and Collecting Optics

1. Viewing windows and diffuse display screens shall be designed to maintain laser radiation below MPE at the viewing location [Required]
2. Interlocks, filters and attenuators shall be used to keep laser radiation transmitted through collecting optics at or below the MPE. [Required]
3. Collecting optics housings containing laser protective filters shall be labeled with the OD and wavelength from which the filter provides protection. [Required]

Beam Paths

1. Control of the beam path shall be accomplished as described below. [Required 3B and 4]
    a. If the beam path is fully open a laser hazard evaluation shall be conducted [Required 3B and 4]
    b. If the exposed path of the beam is limited a laser hazard evaluation shall be conducted. [Required 3B and 4]
    c. If the beam path is fully enclosed, and the enclosure meets all requirements of a protective housing, then the laser will be considered Class 1 and no other control measures will be necessary. If the beam enclosure is temporarily opened (such as during service or repair) then appropriate control measures shall be implemented. [Required 3B and 4]

Remote Interlock Connector

1. A remote interlock connector should be provided on Class 3B lasers. [Recommended 3B]
2. A remote interlock connector shall be provided on Class 4 lasers. [Required 4]

Beam Stop or Attenuator

1. A permanently attached beam stop or attenuator should be provided on Class 3B lasers to prevent laser radiation in excess of the MPE when laser output is not needed, e.g., during laser warm-up. [Recommended 3B]

a. If no laser warm-up time, then the power switch can be used instead of a beam stop or attenuator.

2. A permanently attached beam stop or attenuator shall be provided on Class 4 lasers to prevent laser radiation in excess of the MPE when laser output is not needed, e.g., during laser warm-up.[Required for 4]
    a. If no laser warm-up time, then the power switch can be used instead of a beam stop or attenuator.

Laser Area Warning Signs and Activation Warnings

1. The laser area must be posted with an appropriate warning sign [Required 3B and 4]
2. Temporary laser controlled area must be posted with Notice sign [Required 3B and 4]
3. Activation Warning System [Recommended 3B, Required 4)
    a. Audible warning during laser power supply charge; sounds unique to laser operation are acceptable
    b. Visible warning devices such as red light or lighted laser in use sign visible in the area

Indoor Laser Controlled Area

1. A laser controlled area shall be established if a laser hazard analysis shows accessible radiation is Class 3B or 4 [Required]

2. Class 3B indoor laser controlled areas shall: [Required]
    a. allow access only to personnel trained in laser safety,
    b. be posted with an ANSI-formatted warning sign, and
    c. have a well defined beam path.
3. Class 3B indoor laser controlled areas should: [Recommended]
    a. be under the direct supervision of a person trained in laser safety,
    b. limit access to spectators and require approval for spectator access,
    c. provide an appropriate beam stop for the laser,
    d. have only diffusely reflecting material near the beam path,
    e. provide laser protective eyewear,
    f. have the exposed beam path above or below eye level of a seated or standing person,
    g. have windows, doorways, etc. covered or restricted so that laser radiation is at or below the MPE, and
    h. require that the laser be disabled (for example by removing and storing the key for the master switch) when not in use.

4. Class 4 indoor laser controlled areas shall: [Required]
    a. allow rapid entry and egress in emergency conditions,
    b. allow only personnel trained in laser safety to enter the area
    c. provide laser protective eyewear and any other necessary personal protective equipment,

d. require adherence to all administrative and procedural controls,
e. provide a clearly marked emergency stop switch to deactivate the laser or reduce the laser output to at or below the MPE,
f. provide entryway controls suitable for a Class 3B indoor laser controlled area AND shall incorporate one of the following additional controls:
    i. Non-defeatable area or entryway interlocks shall be used to reduce laser radiation to at or below the MPE in the event of an unexpected entry,
    ii. Defeatable area or entryway controls shall be used if non-defeatable interlocks will prevent the intended use of laser. Defeatable interlocks shall be used only if it is clear that the MPE will not be exceeded at the point of entry. All persons with access shall have completed laser safety training. Personal protective equipment (e.g., laser protective eyewear) shall be provided for all persons with access.
    iii. Procedural area or entryway safety controls (no interlocks) shall be used only when interlocks are not feasible. When procedural entryway controls are used:
        1. all personnel shall complete laser safety training,
        2. personal protective equipment shall be provided prior to or immediately upon entry,
        3. a barrier shall be used such that laser radiation will not exceed the MPE at the entryway, and
        4. an activation warning system shall be located at the entryway indicating that the laser is energized and operating at Class 4 levels.

5. Temporary laser controlled areas shall be used when panels or protective housings are removed, or when protective housing interlocks are overridden and the laser radiation exceeds the MPE. [Required all laser classes]
    a. An ANSI-formatted "NOTICE" sign shall be posted along with the applicable Class 3B or 4 ANSI-formatted warning sign.

6. Class 4 lasers should be controlled and monitored as far as possible from the emission portal of the laser. [Recommended 4]

7. Equipment labels shall be present on each laser. Equipment labels shall include: [Required all laser classes]
    a. a warning logotype label on both the laser and the control if separated by more than 2 meters,
    b. a protective housing label, and
    c. a beam conduit label every 3 meters for long distance beam conduits.

Administrative and Procedural Controls

1. Standard operating procedures should be written and maintained for users of Class 3B lasers [Recommended 3B]

2. Standard operating procedures shall be written and maintained for users of Class 4 lasers [Required 4]
3. Laser safety training shall be completed by all Class 3B an 4 laser users. [Required 3B and 4]
4. Class 3B and 4 lasers shall be operated only by authorized personnel. Authorized personnel are Laser Supervisors and Laser Users that have registered and completed laser safety training. [Required 3B and 4]
5. Alignment standard operating procedures should be written for Class 3B laser setup and/or alignment. [Recommended 3B]
6. Alignment standard operating procedures shall be written for Class 4 laser setup and/or alignment. [Recommended 3B]

Protective Equipment

1. When other controls do not reduce laser radiation to at or below the MPE, protective equipment should be provided for Class 3B laser use. [Recommended 3B]
2. When other controls do not reduce laser radiation to at or below the MPE, protective equipment shall be provided for Class 4 laser use. [Required 4]
3. Laser protective eyewear and protective clothing shall be used for open beam UV lasers. [Required 3B and 4]
4. Facility windows located within the NHZ shall be provided with appropriate barriers or filters to reduce the transmitted laser radiation to at or below the MPE. [Required 3B and 4]
5. Laser protective barriers and curtains should be used inside the controlled area to prevent laser light in excess of the MPE from exiting the entryway. [Recommended 3B and 4]
    a. When laser protective barriers or curtains are used, they shall be selected to withstand direct and diffusely scattered beams and shall have a damage threshold for beam penetration for a specific exposure time.
    b. Selection of the barrier shall take into account the factors of flammability and decomposition products of the barrier material following laser exposure.
6. All laser protective equipment shall be labeled [Required Class 3B and 4] as follows.
    a. Laser protective eyewear shall be labeled with the OD and wavelength(s) for which protection is afforded.
    b. Laser protective windows that are purchased as other than an integral part of the laser shall be labeled with the OD and wavelength(s) for which protection is afforded.
    c. Collecting optics housings containing laser protective filters shall be labeled with the OD and wavelength(s) for which protection is afforded.
    d. Laser protective barriers that are purchased as other than an integral part of the laser shall be labeled with the barrier exposure time and beam conditions under which protection is afforded (e.g., the irradiance in W/cm2).
    e. Laser protective viewports and films that are purchased as other than an integral part of the laser shall be labeled with the OD and wavelength(s) for which protection is afforded.

7. Skin protection shall be used with Class 3B and 4 ultraviolet lasers if chronic exposure to at or near the MPE for skin is expected.

Area Warning Signs

1. Area warning signs shall be in the ANSI format in accordance with ANSI standards, [Required 3B and 4]
2. Class 3B and 4 laser warning signs shall use the signal word "DANGER". [Required 3B and 4]
3. Temporary laser controlled areas shall have an additional sign with the signal word "NOTICE".
4. Warning signs shall include the following information: [Required 3B and 4]
    a. In the upper panel:
        i. DANGER to the right of the safety alert symbol which is a white equilateral triangle with a red exclamation point.
    b. In the lower panel:
        ii. A red laser burst symbol with a tail extending to the right.
            1. Above the tail of the laser burst
                a. Laser protective eyewear requirements
                b. Visible or invisible laser radiation notification
                c. Knock before entering
                d. Do Not Enter When Light is On
                e. Restricted Area
            2. Below the tail of the laser burst
                a. Type of laser
                b. emitted wavelength
                c. pulse duration
                d. maximum output
            3. Class of the laser at the bottom right
5. Warning signs shall be located where best to warn onlookers. [Required 3B and 4]

Equipment Labels

1. Equipment labels shall conform to the following, the Federal Laser Performance Standard or the IEC 60825-1 (or latest revision). [Required 3B and 4]
    a. Class 3B laser equipment labels shall read "Laser Radiation – Avoid Direct Exposure to Beam" above the tail of the laser burst.
    b. Class 4 laser equipment labels shall read "Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation" above the tail of the sunburst.
    c. For Class 3B and 4 laser equipment labels, the type of laser, wavelength, pulse duration (if applicable) and maximum output shall be included below the tail of the laser burst.
    d. The class of the laser shall be listed in the bottom right portion of the equipment label.

FREQUENTLY ASKED QUESTION (FAQ)

Why is there a laser safety program?

Many lasers are capable of causing eye injury to anyone who looks directly into the laser beam, or even at a specular (mirror-like) reflection of the beam. In addition, diffuse reflection of a high-power, Class 4 laser beam can produce permanent eye damage.

High-power laser beams can also burn exposed skin, ignite flammable materials, and cause the release of hazardous fumes, gases, and debris.

Other hazards associated with the equipment and optical apparatus required to produce the lasing action and control the beam can include high-voltage, high pressure, compressed gases, cryogenics, noise, ionizing and non-ionizing radiation, and toxic materials.

Despite the potential hazards, laser equipment can be operated safely if the proper procedures and necessary precautions are followed.

Is my laser dangerous?

Locate the class label on the laser. All lasers sold in the US have one. This will tell you if it is class 1, 1M, 2, 2M, 3R, 3B or 4. Class 3a was also used prior to 2007. Dangers of a class 1, 1M 2, 2M, 3a or 3R laser are much less significant than those of a class 3B or 4 laser. Even for these low power class lasers, however, direct exposure of the eye to the output beam can be dangerous. In addition, many of these lasers, regardless of class, have high-voltage power supplies that can be hazardous.

If you have a class 3B or 4 laser, yes, it is potentially dangerous, and you need to be careful.

I have a class 3B or 4 laser. What makes it dangerous to me?

Of foremost concern is the danger the laser poses to your eyesight. Irreparable damage to parts of your eye, and permanent partial or full loss of vision are possible. Lack of knowledge and training in laser safety is easily remedied and immensely valuable to helping you work safely.

High-power lasers usually have large power supplies designed to deliver large currents, often at high voltages. Accidents during troubleshooting can be fatal. Untrained personnel should stay out of the high voltage power supplies and away from capacitors.

There have been incidents where high-power lasers have ignited laboratory equipment, leading to fire and smoke damage to the laboratory.

There may be a risk of skin damage from direct exposure to the beam.

Excimer lasers make use of reactive gases requiring special safety precautions and procedures to prevent exposure.

How each of the above risks affects you depends on the type of laser, the wavelength, pulse energy (or power for a continuous wave laser), pulse duration (or exposure duration for a continuous wave laser), and the type of application.

I'm new to lasers. How do I figure out what to be concerned about in my lab?

Ask your Laser Supervisor about it.

Ask your Laser Supervisor about the laser safety training provided through the Department of Environmental Health and Safety Radiological Safety Office. The telephone number is 852-5231.

What is the danger to me?

Depending on the wavelength of the laser light, your cornea, lens, or retina may absorb the light. When there's too much absorption, the cells are burned, leading to damage.

Effects on the skin are both photochemical and thermal depending on the wavelength of the laser light. Symptoms range from mild reddening (erythema) to blistering and charring. Also, there are possible carcinogenic effects.

Non-beam hazards include fumes, compressed gases, cryogenic materials, noise, electrical hazards, fire, explosion, and collateral radiation.

How do I know how much laser radiation is too much?

Refer to the American National Standard for Safe Use of Lasers, ANSI Z136.1, for hazard analysis of several different laser types.

How can I avoid accidental exposure?

Follow the Laser Standard Operating Procedure for your laboratory. A template is available in this manual. Contact the Radiation Safety Office if you have any questions.

Use correct approved laser safety goggles when appropriate. The lenses in goggles are for a specific wavelength range, and do not protect you outside of this range. Even with goggles, consider direct exposure to a laser beam to be dangerous.

Question practices which appear unsafe to you. Are they necessary or outdated? Can the same function be performed in a manner which is less dangerous? Can the unsafe practices be replaced by some other diagnosis or measurement? Are work practices designed for expediency at the expense of safety?

Where can I get more laser safety information at U of L?

Laser safety information is available in this program, at the DEHS Radiation Safety website.

Where can I find out about procedures at U of L?

Procedures for the safe operation of a laser can be found in this document. Discussion is made of features that should be designed into the laser and the laboratory, as well as information on procedural and administrative policies.

Procedures at U of L are based on the guidelines developed by American National Standards Institute (ANSI) in ANSI Z136.1 – Safe Use of Lasers. Contact the LSO for information on purchasing a copy of the current ANSI standard.

GLOSSARY OF TERMS

Accessible Emission Limit (AEL)- The maximum accessible emission level which is permissible in the appropriate class of laser.

Accessible Radiation- Laser radiation that can expose human eyes or skin in normal usage.

Aperture- The opening in the optical cavity through which the laser beam passes.

Average Power- Total energy of an exposure divided by the duration of the exposure.

Aversion Response- A voluntary or in-voluntary reflex action to avoid exposure to laser light.

Beam Diameter- The diameter of the laser beam where the power per unit area of the beam is 1/e times the peak power per unit area.

Continuous Wave (CW) Laser- A laser which has a continuous output that is greater than or equal to 0.25 seconds.

Infrared Radiation (IR)- Electromagnetic radiation with wavelengths between 700 to 1000 nanometers (nm).

Irradiance- Power per unit area as expressed in watts per centimeter.

Laser Safety Officer- An individual given the authority to monitor and enforce laser safety and control by management.

Maximum Permissible Exposure (MPE)- The maximum level of laser radiation to which human tissues can be exposed without adverse biological effects.

Nominal Hazard Zone (NHZ)- A zone or area in which direct, reflected or scattered laser light exceeds the MPE.

Nominal Ocular Hazard Distance (NOHD)- The distance along the axis of the direct laser beam for which the human eye will not receive a level of laser light above the MPE.

Pulsed Laser- A laser whose output energy in single or multiple pulses are less than or equal to 0.25 seconds.

Radiant Energy- A measure of the output energy of a laser expressed in Joules (J).

Radiant Exposure- A measure of output energy per unit area expressed in joules per square centimeter (J/cm^2).

Radiant Power- A measure of output power expressed in Watts (W)

Pulse Repetition Rate (PRR)- The frequency of laser output pulses expressed in Hertz (Hz).

Specular reflection- Mirror like reflections that can produce adverse biological effects similar to direct laser beam effects.

Ultraviolet Radiation (UV)- Electromagnetic radiation with wavelengths from 180 to 400 nanometers (nm).

Visible Radiation Electromagnetic radiation which is visible to the human eye.