Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this document is to provide guidelines for protection from workplace hazards associated with the use of Class 3B and/or Class 4 lasers. This purpose is to be accomplished through the implementation of administrative and engineering controls and the use of eyewear/ personal protective equipment (PPE) as prescribed in the American National Standards Institute's American National Standard for the Safe Use of Lasers – ANSI Z136.1 – 2022. While some departments or entities within Emory University may have additional and/or more stringent guidelines for the safe use of Class 3B and Class 4 lasers, the guidelines outlined in this document shall serve as the minimum requirements for all of Emory University.

1.2 Scope

The Laser Safety Program applies to all Emory University employees, students and to employees of Emory Healthcare who operate laser equipment classified as Class 3B and/or Class 4 or who work in areas where these classes of lasers are used. It also applies to any other individuals who may visit or have access to these areas at any time. See Appendix B for a summary of the differences between Emory University and Emory Healthcare.

1.3 Definitions

Accessible emission limit (AEL). The maximum accessible emission level allowed within a particular class of lasers.

Aversion response. Movement of the head or blinking of the eyelids in response to a stimulant such as a bright light. Normal aversion response is assumed to occur within 0.25 seconds of exposure to the stimulant.

Continuous wave. The output characteristic of any laser system that operates in a continuous mode, or as referred to in ANSI Z136.1, having a continuous output for greater than 0.25 seconds.

Deputy Laser Safety Officer (DLSO). An individual who has been authorized by the LSO the authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards. This individual has the training and experience to administer a laser safety program and has responsibility and oversight for laser hazards.

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

EHSO. Environmental, Health, and Safety Office.

Embedded laser. An enclosed laser that has a higher class than that of the laser system in which it is enclosed; the lower classification of the system is appropriate due to engineering controls of the laser system and the limitation of its emission.

Hazard. Any condition that has the capacity to cause injury or adverse effects to the exposed individual(s).

Intra-beam viewing. The viewing condition whereby the eye is in the direct path of the laser beam.

Irradiance. Radiant power incident per unit area upon a surface, given as watts per centimeter squared.

Laser or LASER. A device that produces radiant energy by stimulated emission, also an acronym for Light Amplification by Stimulated Emission of Radiation.

Laser generated air contaminants. Respirable materials that have the potential to cause adverse effects to those exposed and are produced as a result of the heating of target materials by lasers.

Laser equipment / laser system. An assembly of electrical, mechanical and optical components which includes a laser.

Laser Operators. The physician(s) responsible for operating the laser.

Laser Safety Contact (LSC). Individual(s) who has been authorized by the DLSO to serve as a delegate of the DLSO at a specific site, building or laboratory. This individual has responsibility for all aspects of laser safety at the site, building or laboratory. The main contact for the site may be admin, training specialist, technologist, etc. This person will act as liaison between EHSO and the department.

Laser Safety Officer (LSO). An individual who has the authority to monitor and enforce the control of laser hazards and affect the knowledgeable evaluation and control of laser hazards. This individual has been authorized by the administration and is responsible for the laser safety program. This individual also has the training and experience to administer a laser safety program and has responsibility and oversight for laser hazards.

Laser Safety Specialist (LSS). An individual who has been trained on laser usage.

Limiting aperture. The diameter of a circle over which irradiance or radiant exposure is averaged for purposes of hazard evaluation and classification.

Maximum permissible exposure (MPE). The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eyes or skin.

Nominal hazard zone (NHZ). The space within which the level of direct, reflected, or scattered radiation during normal operation of a laser exceeds the applicable MPE.

Optical density (OD). Logarithm to the base ten of the reciprocal of the transmittance. Optical density is a critical factor in the selection of appropriate eye protection in the protection from exposure to laser radiation.

Power. The rate at which energy is emitted, transferred or received.

Protective housing. The encasement of a laser that prevents exposure to laser radiation in excess of the applicable MPE level.

Pulsed laser. A laser that emits radiation in a pulse or series of pulses.

Q-switched laser. A laser that emits short (~10-250 ns), high power pulses by means of a Q-switch.

Radiant exposure. Surface density of the radiant energy received in the form of radiation. Given in units of joules per centimeter squared.

Safety interlock. An interlock where the failure of a mechanical or electrical component of the interlock will cause the system to go into safe mode.

Specular reflection. A mirror like reflection.

Transmittance. The ratio of transmitted power to incident power.

Wavelength. The distance between two successive points on a periodic wave having the same pulse.

1.4 Responsibilities

Laser Safety Committee

A laser safety committee may be created when the number of lasers, types of hazards and complex applications are substantial. This committee is housed under the Radiation Control Council (RCC). The committee will consist of professionals from multiple fields of expertise and are responsible for:

- Providing guidance and/or feedback on laser safety issues.
- Evaluating all content revisions to laser safety guidelines, training and proposed control measures.
- Informing the LSO of any recognized laser safety issues in their area of expertise.
- Reviewing incidents.

Environmental Health and Safety Office (EHSO)

As the administrative department for the Laser Safety Program, EHSO is responsible for:

- Appointment of the LSO for Emory University and Emory Healthcare, as prescribed by Section 1.3.2 of ANSI Z136.1-2022.
- Appointment of DLSOs.
- Review and approval of the Laser Safety Program and any amendments made by the LSO.
- Enforcement of the Laser Safety Program.
- Retention of all training and inspection records in accordance with ANSI Z136.1-2022 American National Standard for Safe Use of Lasers.

Laser Safety Officer (LSO) and Deputy Laser Safety Officer (DLSO)

The LSO represents EHSO as the program administrator for laser safety and is responsible for:

- Development of the written Laser Safety Program and all necessary amendments.
- Compiling and maintaining (as needed) a laser system/device inventory for all Class 3B and Class 4 lasers.
- Ensuring that all Class 3B and Class 4 lasers are marked with the appropriate designation from the manufacturer including: warning labels, power, and wavelength. If this is not the case, the LSC must contact the manufacturer to provide the appropriate designation.
- Ensuring periodic maintenance and service is performed on all lasers at designated intervals (biomed, GE, manufacturer, etc.).
- Assessment of hazardous conditions or potential hazards in work areas where lasers are used.
- Recommending and/or implementing control measures to remedy hazardous conditions in the areas where lasers are used.
- Investigating all accidents and/or injuries that occur as a result of laser operation.
- Examining and approving all forms eye personal protective equipment used in the laser work environment. The DLSO shall conduct these examinations periodically to ensure that all eyewear is adequate, in satisfactory condition, and to determine whether replacements are necessary.
- Ensuring that all labs or work areas where lasers are used have signage on the exterior door(s) indicating the presence of laser equipment.
- Ensuring initial manufacturer's training and General Laser Safety training is completed via EHSA and/or HLC by laser safety contacts and specialists prior to use of lasers; Continuing education should be conducted by the manufacturer as needed or via EHSA/ HLC if there have been significant changes to the ANSI standards either for remediation or changing regulation.
- Performing annual inspections to ensure that implemented control measures are being followed, procedures are conducted in a safe manner, and PPE is in good working condition. During each inspection, an inventory will be conducted to ensure that all lasers are accounted for, new equipment has been registered, and surplus equipment has been removed from the inventory.
- The LSO may delegate these responsibilities to the DLSO as necessary.

Directors, Supervisors, and Managers/Principal Investigators - Laser Safety Contacts (LSC)

The LSC has primary responsibility for providing a safe work environment for their employees that work in areas where lasers are used. They are responsible for:

- Providing written Standard Operating Procedures for work practices using Class 3B and Class 4 lasers to laser specialists, laser operators, and the DLSO. SOPs should include items such as the description of laser(s) used, laser specifications, operating and safety procedures and all PPE used during operation.
- Implementing control measures that minimize potential hazards associated with

laser use.
- Maintaining an up-to-date inventory of all Class 3B and Class 4 lasers that fall under their authority by registering the devices in EHSA.
- Obtaining initial laser training from the manufacturer at time of installation and any additional training as recommended by the manufacturer.
- Ensuring that all laser specialists have completed General Laser Safety training in EHSA and/or HLC.
- Providing all laser specialists with hands-on training on the operation of the specific Class 3B and Class 4 lasers they will be operating.
- Providing all laser specialists and operators with adequate personal protective equipment for use with lasers, particularly adequate eye protection.
- Notifying the DLSO of any potential hazards associated with laser use not covered in this document.
- Notifying the DLSO of all new personnel who will operate lasers for training purposes.
- Notifying DLSO of any new purchases of Class 3B and Class 4 lasers, or any such equipment that requires transfer and/or decommissioning.
- Notifying the DLSO of any alterations made to laser devices or laser equipment that may elevate their hazard class above that set by the manufacturer.
- Reporting any accidents or injuries, or suspected injuries associated with the use of lasers to the DLSO.
- Contacting the DLSO for any questions regarding laser safety.

Laser Safety Specialists
Individuals who have been trained on laser usage.

- Notifying their PI, supervisor, director, or lab manager or LSC of any unsafe conditions in the work area.
- Completing all required laser safety training.
- Reporting all accidents, injuries, or suspected injuries to the LSC and the DLSO.
- Contacting LSC or DLSO when questions arise regarding the safe use of lasers in the work area.
- Reporting any problems to the LSC regarding eye protection (obvious or suspected).

Laser Operators
The physician that is responsible for operating the laser.
Laser operators are responsible for:
- Complying with all rules set forth in this document.
- Contacting LSC or DLSO when questions arise regarding the safe use of lasers in the work area.
- Reporting any problems to the LSC regarding eye protection (obvious or suspected).

1.5 Training Requirements
The LSO is responsible for ensuring that laser safety training has been completed by those who operate Class 3B and/or Class 4 lasers. Initial training for new equipment

should be provided by the manufacturer upon installation. General Laser Safety training will be completed through the HLC or EHSA platform one-time. Continuing education will be provided by the manufacturer as needed or via EHSA/ HLC if there have been significant changes to the ANSI standards. For all laser safety contacts/specialists and may include the following:

- Basic concepts about laser devices.
- Biological effects of laser radiation on the eyes and the skin.
- The significance of specular and diffuse reflections of laser radiation as they relate to eye injuries.
- Classification rationale for laser devices and laser systems.
- Hazards associated with the use of Class 3B and Class 4 lasers that are not directly related to the laser beam.
- Implementation of control measures as methods of injury prevention.
- Selection, use, and appropriate care of eyewear.
- Continuing education will be given to laser contacts/ specialists at the discretion of the LSO to ensure that the most current information is being provided as updated ANSI standards are released and as new developments are made in the field.

1.6 Recordkeeping

- Training and inspection records are retained with EHSO and available in accordance with the ANSI Z136.1-2022 Standard for the Safe Use of Lasers.
- Maintenance and service records are retained with the LSC or Biomed (medical facilities).
- Assessments of hazardous conditions or potential hazards in work areas where lasers are used are maintained by EHSO.
- Laser inventory is maintained by individual departments and registered with EHSO through the EHSA platform within 30 days of receipt.
- Hazard signage prepared by the LSO or DLSO is maintained by EHSO.

1.7 Program Evaluation

The LSO and DLSO are responsible for the evaluation of the Laser Safety Program to ensure that its components work effectively in the protection of Class 3B and Class 4 laser operators. Laser systems that have been reclassified as Class 1 systems due to design are exempt from EHSO's annual audit.

- As part of the evaluation process, the Laser Safety Officer will conduct annual safety inspections. During the inspection process, the LSO will complete the following tasks:
    - Inspect all laser work areas for imminent beam and non-beam hazards.
    - Consult LSC, laser specialists, and laser operators for their comments and/or concerns regarding laser safety.
    - Investigate and document any incidents, accidents and/or injuries associated with laser use that have been recorded by the LSC or employees.
    - Inspect all laser eye protection for appropriate storage, chips, cracks and deterioration.

- Ensure all devices have been registered with EHSO through the EHSA platform and to ensure that any device that has been decommissioned has been removed from the inventory.
- Ensure that all laser workers have been added to the laser permit.
- Ensure that initial and General Laser Safety training has been completed.

2.0 Policy

Emory University is committed to the minimization of accidents and/or injuries caused using Class 3B and/or Class 4 lasers. The main goal is to ensure that all exposures to laser radiation (both to the eyes and skin) are kept below the applicable maximum permissible exposure (MPE) limit. This will be accomplished through training and education of personnel on laser safety and the use of administrative controls, engineering controls and PPE. For determination of its effectiveness and for any necessary amendments, this Laser Safety Program will be re-evaluated periodically.

While this program addresses hazards associated with the use of Class 3B lasers, Class 4 lasers and any non-beam hazards associated with the laser work environment, any hazardous conditions encountered that are not addressed by this document should be reported to EHSO for investigation.

3.0 Laser Safety in Medical Facilities

The ANSI Z136.1-2022 Standard provides guidance for the safe use of laser devices and laser systems. The American National Standards Institute also offers standards that are more specific to laser use in healthcare facilities: Z136.3 Standard for Use of Lasers in Healthcare Facilities. Although the Z136.3 Standard is specific to healthcare facilities, it is intended to be followed in addition to the Z136.1 Standard.

4.0 Laser Classification

4.1 Class 1 Lasers

- Lasers or laser systems that are incapable of producing laser radiation levels in excess of the Class 1 accessible emission limit (AEL) values for any period of time during normal operation is considered a Class 1 laser (see Section 3.2 of ANSI Z136.1 for AEL values). In many cases, there are lasers of higher classes that are responsible for the laser output of these lasers, but the beam may be enclosed in a protective housing that prevents the higher energy from escaping. The output capacity during normal operation is what determines the laser class. They can be divided into two subclasses:
- Class 1 lasers or laser systems are considered exempt from all control measures or any other types of safety measures by the ANSI Z136.1 and are therefore exempt from the Laser Safety Program. In circumstances where the protective housing of the laser may need to be opened, the requirements for embedded lasers apply.
- Class 1M lasers or laser systems are not capable of emitting accessible laser radiation that exceeds the Class 1 AEL under normal operating conditions. However, they exceed the Class 1 AEL for telescopic viewing, but do not exceed

the Class 3B AEL. Class 1M lasers are exempt from all control measures other than those that protect against potentially hazardous optically aided viewing (appropriate protective viewing filters).

4.2 Class 2 Lasers

- Class 2 lasers or laser systems emit energy at wavelengths that cover the entire visible portion of the electromagnetic spectrum. These are lasers that can be continuous wave (CW) or repetitively pulsed and can produce output energy exceeding the Class 1 AEL value for the maximum duration intended in the design of the device. Lasers in this class are fairly low power lasers, considering the average power emitted within the class does not exceed 1 milliwatt (mW). They can be divided into two subclasses:
  - Class 2 lasers are those that are not intended to be viewed directly while in normal operation. Class 2 lasers would not pose a significant hazard during normal operation but would prove hazardous if viewed directly for extended periods of time. The normal human aversion response time (0.25 seconds) would suffice in protecting the eyes. Because no other control measures are needed, Class 2 lasers are exempt from the Laser Safety Program.
  - Class 2M lasers are not capable of emitting accessible laser radiation that exceeds the Class 2 AEL under normal operating conditions. However, they exceed the Class 2 AEL for telescopic viewing, but do not exceed the Class 3B AEL. Class 2M lasers are exempt from all control measures other than those that protect against potentially hazardous optically aided viewing (appropriate protective viewing filters).

4.3 Class 3 Lasers

- Lasers or laser systems in Class 3 are divided into two subclasses as well: Class 3R and 3B. No fire hazard exists for either subclass. Neither subclass can produce hazardous diffuse reflections. Always ensure all appropriate protective viewing filters are in place.

Table 4.1 – Class 3 Lasers

LASER CLASS	AEL	INTRABEAM VIEWING	HAZARDOUS WITHIN NORMAL AVERSION TIME (0.25 SECONDS)	CONTROL MEASURES
3R	1x-5x AEL of Class 1 or 2	Marginally unsafe	No	No additional controls needed unless viewed through collecting optics.
3B	In Excess of Class 3R	Unsafe	Yes	See Section 6.1.

- Class 3B lasers include those that operate in the ultraviolet and infrared regions of the electromagnetic spectrum and can emit laser energy in excess of the AEL values of Class 3R lasers during any period of time, and can emit power of less than 500 milliwatts (mW).
- Class 3B also includes lasers in the visible and near infrared portions of the

spectrum and can emit power from 5.0 – 500 milliwatts (mW) via continuous wave or greater than 0.03 joules (J) per pulse (for pulsed lasers).
- Since the normal aversion time does not protect the eye from Class 3B laser radiation, class 3B lasers are covered under the Laser Safety Program.

4.4 Class 4 Lasers

- Lasers and laser systems in Class 4 are those that emit laser radiation levels that exceed the AEL values of Class 3B.
- Class 4 lasers can produce hazards from direct viewing as well as diffuse reflections. They can emit power in excess of 500 milliwatts (mW) and direct viewing and diffuse reflections can cause eye injury within the normal aversion time (less than 0.25 seconds).
- This class of lasers can also have the potential to cause skin hazards/injuries and fires.
- Class 4 lasers can cause injury to the eyes by direct viewing and by diffuse reflections. The normal aversion time does not protect against the laser radiation. The laser radiation can cause injury to the eyes, skin and can cause fires.
- Lasers of Class 4 are covered under the Laser Safety Program.

4.5 Alternate Laser Classification

The classification scheme used in this section is prescribed by the ANSI Z136.1 standard. However, some laser devices on campus may be labeled using an alternate classification scheme. The International Electrotechnical Commission (IEC) and the Center for Devices and Radiological Health (CDRH) both have classification schemes for lasers that are similar to that of ANSI but have minor differences (see Appendix A - Summary of Laser Classification Schemes for additional information regarding these schemes).

Lasers and laser systems that are manufactured on campus must be classified and labeled as indicated above. The LSO will provide additional guidance on classification and labeling for such devices.

5.0 Laser Registration

The LSC must inform the LSO of any existing lasers and new purchases of laser devices or laser equipment of Class 3B and Class 4 by registering/providing a current inventory of devices. See Table B for more details.

6.0 Control Measures for Laser Operation

Control measures must be implemented to ensure that all laser operators and any other at-risk individuals, such as spectators and service personnel, are protected from Class 3B and Class 4 laser radiation. These control measures have a broad range from simple administrative controls such as training, signage, and restricted access, to minimizing possible exposure to the beam, to eye protection to protect individuals from the beam. The goal is to ensure the work environment is as safe as feasible without disrupting the work process.

6.1 Class 3B Lasers

The following control measures must be implemented as prescribed by the ANSI Z136.1 standard to protect against Class 3B laser radiation:

- Individuals who operate Class 3B lasers shall be trained in general laser safety aspects and must be authorized by the LSC to operate the equipment.
- The path of the laser beam shall be enclosed as much as feasible.
- When full output of the laser is not required, all shutters and filters on laser equipment shall be used to minimize hazardous levels of laser radiation.
- No individual shall point the laser beam of a Class 3B (or any) laser at or in the direction of the eyes of another person.
- No individual using lasers shall position his or her unprotected eyes near or within the path of the laser beam.
- No individual shall knowingly allow another person to position his or her unprotected eyes near or within the path of the laser beam.
- Any individual who operates a Class 3B laser or is a spectator during the operation of the laser shall wear adequate eye protection for the laser in use. For unique situations (such as multiple open beams in operation simultaneously), a hazard assessment may be needed.
- The presence of reflective surfaces (hanging mirrors, jewelry, etc.) shall be prohibited from the work environment while the laser is in operation in order to prevent unwanted reflections that may cause injury.
- Protective housings must be secure on the laser device.
- In the event that the protective housing must be removed, the laser must have a safety interlock system that can be activated.
- Service access panels (removed only when servicing the laser) must be interlocked, must require a tool for removal and have an appropriate warning label.
- Aiming lasers in the direction of windows, doorways, or the windows of doors shall be prohibited.
- No individual shall operate the laser prior to specific control measures (for the laser work area) being implemented.

6.2 Class 4 Lasers

The following control measures must be implemented as prescribed by the ANSI Z136.1 standard for Class 4 lasers **IN ADDITION TO** those control measures outlined for Class 3B lasers:

- During operation, the path of a Class 4 laser beam shall be completely enclosed where feasible to reduce hazards.
- In cases where beam enclosure is not feasible, remote operation should be utilized where possible.
- Any individual who operates a Class 4 laser or is a spectator during the operation of the laser shall wear adequate eye protection for the laser in use. For unique situations (such as multiple open beams in operation simultaneously), alternate control measures (i.e. remote operation, closed circuit television, etc.) are strongly recommended.
- Class 4 lasers shall have an operational key switch to prevent unauthorized use.
- For laser devices that have key switches to prevent unauthorized use, the key must be removed from the device when unattended.

- To diminish fire hazards, fire resistant, absorbent target material and beam stops, and attenuators shall be used.
- Countdown devices or verbal countdowns should be used to inform laser operators of exactly when the laser beam will be emitted.
- The laser equipment should be equipped with remote interlock connectors.

6.3 Embedded Lasers

- Embedded lasers, under normal operational circumstances, are exempt from EHSO's annual audit program and registration if the manufacturer explicitly designates the system as a Class 1 laser system. This is due to protective housing and safety interlocks that are installed by the manufacturer.
- However, in some cases, while being serviced, the protective housing and safety interlocks of the laser may need to be removed. Therefore, while being serviced, temporary control measures must be implemented according to the laser classification.
- If the protective housing and/or safety interlocks are malfunctioning or are defeated, the laser equipment has the potential to cause injury to the eyes through exposure to Class 3B or Class 4 laser radiation. This must be reported to the LSO immediately and the laser shall be taken out of service until it is repaired.

6.4 Multiple Wavelength Lasers

- Some lasers have the capability to operate at multiple wavelengths of the electromagnetic spectrum, which also enables them to produce a broad spectrum of hazards depending on their operational wavelengths. Multiple wavelength lasers must be classified according to the highest potential for hazard.
- The appropriate control measures outlined in this document will be implemented for multiple wavelength lasers when they are operational as Class 3B or Class 4 lasers.

6.5 Ultraviolet Lasers

- For lasers that are used in the ultraviolet region of the electromagnetic spectrum (180 nm – 400 nm), additional caution should be taken when in operation. Whether the hazard class of the laser is Class 3B or Class 4, the following precautions should be taken **IN ADDITION TO** those of its respective hazard class:
- Minimization of UV radiation by use of beam shields.
- Minimization of UV radiation by wearing clothing that attenuate radiation levels to below the applicable MPE for specific wavelengths (e.g.– lab coats).

6.6 Lasers with Invisible Beams

Lasers that operate in the IR and UV wavelengths of the electromagnetic spectrum are invisible to the human eye. Because these laser beams cannot be seen, the potential for accidents and injuries is greater. Always use adequate eye protection when operating (Class 3B and Class 4) IR and UV lasers.

7.0 Control Measures for the Work Environment

Control measures must also be implemented with regard to the laser work area and its physical orientation to ensure that the work environment is safe for all personnel. The following control measures must be implemented as prescribed by the ANSI Z136.1 standard regarding the laser work area.

7.1 Nominal Hazard Zone (NHZ)

For work environments where Class 3B or Class 4 lasers are used, a nominal hazard zone, or NHZ must be established when necessary. The purpose for the establishment of the NHZ is to determine where the hazards associated with exposure to Class 3B or Class 4 lasers end and the safe, laser hazard-free areas begin within the work environment. The establishment of the NHZ is the responsibility of the manufacturer. In certain situations, it may be practical to designate an entire laser work area as the NHZ.

7.2 Positioning of Laser Equipment

- Laser equipment should be positioned in the work environment using the following methods where feasible:
- The laser or laser system shall be positioned at a level above or below eye level where feasible to prevent direct exposure to the beam, reflections, or scattered laser radiation.
- All laser equipment shall be securely mounted on a sturdy surface to prevent unintended distribution of the laser beam.
- All areas of traffic within the work area shall be free of all electrical cords extending from laser equipment to prevent tripping or possible unintended exposure to laser radiation.
- No laser equipment shall be moved and operated away from the currently established NHZ.
- When operating laser equipment, take all necessary precautions when working near surfaces that are wet.

7.3 Alignment Procedures

The possibility for eye hazards/injuries is increased during alignment procedures due to the proximity of the laser operator's eye(s) to the beam. Alignment procedures should not be performed by individuals who have not received training in laser safety. During alignment procedures for Class 3B or Class 4 lasers, the following precautions should be taken:

- Allow only necessary personnel to be present in the work area during the procedure.
- When feasible, use lower power, visible lasers to simulate alignment for higher power lasers.
- Wear adequate eye protection and protective clothing to the extent feasible.
- When available, use beam display devices such as image converter viewers or phosphor cards to locate beams when aligning invisible (and in some cases visible) beams.
- When aligning high power lasers, do so at the lowest possible power level.
- Use shutters or beam blocks to block high power beams at the source, except

when needed during the alignment process.

- Use a laser rated beam block to terminate high power beams down range of the optics being aligned.
- Use beam blocks in conditions where stray beams could expose uninvolved personnel.
- Place beam blocks behind optics (e.g. – turning mirrors) to terminate beams that may miss mirrors during alignment.
- Locate and block all stray reflections before proceeding to the next optical component or section.
- Before operating high power beams, ensure all beams and reflections are properly terminated.
- Post appropriate warning signs during alignment procedures (when lasers are normally Class 1 – in the case of embedded lasers).

7.4 Postings

According to the ANSI Z136.1 Standard, work areas where Class 3B and Class 4 lasers are located must be labeled with posted signage of a three-panel format as follows:

- The first (top) panel contains an appropriate signal word (Danger, Warning, Notice or Caution)
- The second panel contains the laser radiation hazard safety symbol.
- The third, message panel contains the hazard class of the laser-controlled area and the following special precautionary instructions (when pertinent):
    - Laser eye protection required.
    - Invisible Laser Radiation.
    - Knock Before Entering.
    - Do Not Enter When Light is Illuminated
    - Restricted Area, Authorized Personnel Only
    - The highest hazard class of the laser(s) within the laser-controlled area.
    - The optical density of LEP to be worn within the area.
    - The name and contact information for the LSC.

Laser-controlled area signs prepared in accordance with current and previous revisions of ANSI Z136.1 fulfill the requirement of the laser safety program.

The DLSO can prepare signage for a laser-controlled area if signage was not provided by the manufacturer.

8.0 Additional Control Measures

The following additional control measures are prescribed by ANSI Z136.1 for work areas containing Class 3B and Class 4 lasers:

- All doors in work areas containing laser equipment should be locked (when no procedures are ongoing), giving only authorized personnel access to the area. This is to prevent unauthorized access and to prevent inadvertent entry by laypersons during operation.
- Lighted/flashing or hanging warning signs should be posted outside the work area to indicate that a laser is in use.

- All windows and windows built into doors of the work area should be covered with dark, non-penetrable material to confine all laser radiation to the work area.
- Laser operators should not operate laser equipment while working alone. Another laser operator or qualified individual should be present in case of an accident.
- The use of checklists to outline all operational and safety procedures while the laser equipment is in use would ensure that every possible measure is taken to prevent injury.
- It is recommended that individuals working in the laser environment be trained in CPR if there is an injury involving high voltage or respiratory arrest.
- In the event of a fire, an operational fire extinguisher (or appropriate fire method for extinguishing fires) should be available.
- Emergency contact numbers must be posted in the work area in the event of an injury or other hazardous condition.

9.0 Personal Protective Equipment

When working with lasers, the goal for employee protection is to minimize the hazard as much as feasible to prevent exposure to radiation. However, when it is not feasible to minimize exposure, personal protective equipment or PPE must be used as the primary means of protection. **Hazards associated with the use of Class 3B and Class 4 lasers are primarily to the eyes, it is imperative for all employees operating these lasers to wear laser eye protection as determined by the manufacturer's requirements.**

9.1 Eye Protection

The careful selection of eye protection is very important in protecting the eyes against Class 3B and Class 4 laser radiation. There are several factors that must be considered when selecting eye protection. Failure to adhere to such factors could lead to the inadvertent selection of inadequate protection. Optical density (OD) is used to describe laser eye protection's ability to reduce the transmittance of incident laser light. The following factors must be considered when selecting adequate eye protection from Class 3B and Class 4 laser radiation:

- Wavelength of the laser or the spectral range for which protection is needed.
- The OD at the specific wavelength.
- The MPE at the specific wavelength.
- The damage threshold, which is the maximum irradiance or beam power for which the PPE provides protection for a time frame of 10 seconds.
- Laser power or pulse energy (where applicable).
- Limiting aperture.
- Visible light transmission (lasers in visible region), which should be as high as possible to ensure visibility of the laser while wearing the eye protection.
- The visual transmittance for daylight and night, due to the variation in eye sensitivity to different forms of light at these times.
- Field of view provided by design.
- Curvature of the lens.
- Anti-fogging designs.
- Availability of prescription lenses, or sufficient size for prescription lenses to be worn inside.

- Angular dependence of protection afforded.
- Effect on color vision.
- Need for side shield protection and maximum peripheral vision requirement.
- Exposure time criteria.
- Degradation of filter media, such as photobleaching.
- Strength of materials.
- The capability of the front surface to produce a hazardous specular reflection.
- Comfort and fit.

9.2 Calculation of Eye Protection Parameters

The following steps are critical to ensure that the appropriate eye protection is chosen:

- Determine the operational wavelength of the laser and the maximum viewing time period for which the eye protection will be used. This will help determine the applicable MPE of the eye for those parameters (refer to ANSI Z 136.1).
- Determine the potential irradiance or radiant exposure and compare with the MPE.
- Determine the potential over-exposure.
- Determine the OD from the base 10 logarithm of the overexposure.
- With respect to the factors of time, MPE limits, and exposure, the following must also be considered when selecting appropriate eye protection for Class 3B and Class 4 lasers:
    - For visible Class 3B or Class 4 lasers: when long term exposure to visible lasers is not intended, the applicable MPE used to establish the OD requirement for eye protection should be based on an exposure time of 0.25 seconds, which is based on the normal aversion response to bright light. This becomes the initial defense for unexpected exposures.
    - In cases where exposure to a laser beam must exceed 0.25 seconds, such as alignment procedures (when viewing a diffusely reflected target), the applicable MPE used to establish the OD requirement for eye protection may be based on a 600 second exposure, which represents the worst-case time exposure for these tasks.
    - For near-infrared Class 3B or Class 4 lasers: when long term exposure to near infrared lasers is not intended, the applicable MPE used to establish the OD requirement for eye protection should be based on an exposure time of 10 seconds. This represents a realistic worst-case time exposure based on normal eye motions.
    - For diffuse viewing (Class 3B or Class 4 lasers): when viewing an extended source of the diffuse reflection of a beam from a Class 3B or Class 4 laser where intermediate viewing time is intended, the applicable MPE should be based on the maximum viewing time that would be required during any eight-hour period.
    - These conditions are highlighted due to the wavelengths falling within the retinal hazard region, where the most profound injuries to the eyes can occur. If the inappropriate optical density is selected for an exposure condition, the laser radiation will not be decreased below the MPE limit and the resulting energy penetrating the eye protection will cause injury.

9.3 Maintenance of Eye Protection

Eye protection designed to protect against laser radiation should be maintained to ensure effectiveness. The following measures must be taken to ensure that laser eye protection remain effective in protection against laser radiation:

- Each pair of eye protection must be labeled with the appropriate optical density and electromagnetic wavelength (should be labeled from the manufacturer).
- Each pair of eye protection must be inspected periodically for cracks, scratches and breaks that could allow the penetration of laser radiation.
- Each pair of eye protection should be stored in its own protective casing.
- Each pair should be cleaned regularly with mild soap and water as opposed to harsh chemicals to prevent the thinning of the protective coating.
- Eye protection that is suspected to be damaged or not working properly should be examined for functionality or disposed of if dysfunctional.

9.4 Skin Protection

- Although protection of the eyes is the primary concern when operating lasers, the skin should also be protected in particular instances.
- Engineering controls such as beam shields are the best way to protect the skin. However, alternative methods must sometimes be used. For protection from UV radiation (180 nm – 400 nm), the following control measures are recommended:
- Wearing of skin covers.
- Wearing opaque gloves.
- Wearing tightly woven fabrics and/or lab coats.
- Flame retardant clothing is recommended for certain uses of Class 4 lasers.
- When the wavelength of the laser exceeds 1400 nm, overexposure can cause heat loading which can lead to heat stress and skin dryness. In these cases, the recommendation is reduced personnel exposure.

10.0 Non-Beam Hazards and Control Measures

Injuries caused by exposure to laser radiation of Class 3B and Class 4 lasers are the primary focus of the Laser Safety Program. However, there are other hazards that are associated with the use of lasers that also require control measures. These hazards will also be evaluated by the LSO and the appropriate control measures will be implemented accordingly.

10.1 Laser Generated Air Contaminants

- LGACs can be produced as a result of beam contact with metals, fabric, plastics, and human skin. The plumes of smoke or vapors generated can cause respiratory adverse effects when inhaled and can produce biological effects if bacteria or viruses become airborne due to contact with the eyes or skin.
- Local exhaust ventilation is strongly recommended in addition to the negative pressure design in the laser work area to minimize exposure to LGAC.
- The area must have negative pressure to contain any releases.

10.2 Electrical Hazards

Electrical hazards can result from the use of lasers. These hazards can occur during

installation of the equipment, during the servicing of the equipment or because the equipment is not properly grounded. Depending upon the voltage required to operate the equipment, injuries can vary from a minor shock to electrocution. To prevent serious injury or death from electrical hazards, the following precautions must be taken:

- Extreme caution must be used whenever servicing laser power supplies.
- Additional controls and training when working on live circuits operating at more than 50 volts, as prescribed by OSHA 29 CFR 1910 S.
- Maintain the integrity of all electrical cords and terminals.
- Ensure that the equipment is grounded well.
- A clearly visible, power-on indicator should be present.

10.3 Laser Dyes

- Various dyes and solvents are sometimes used (depending on the type of laser) as a lasing medium. Some of these substances are toxic and carcinogenic if absorbed through the skin or swallowed.
- For each dye used with lasers, ensure that safety data sheets (SDS) are available.
- For additional information, visit the EHSO website, where the online SDS database can be accessed.

10.4 Cryogenic Agents and Compressed Gases

- Cryogenic agents are used in conjunction with lasers or laser systems. These substances can cause explosions in the laser work area. Any container or vessel containing cryogenic liquids, which are extremely cold materials, have the potential to explode due to rapid expansion inside the vessel.
- Liquid oxygen is highly flammable, as it contains more oxygen by volume than normal air and should be kept away from all possible sources of ignition. Cryogenic liquids can also cause severe burns and frostbite if handled improperly.
- Compressed gases are often used in the laser work area and can also constitute an explosion hazard. Over pressurization of the container by heating can cause the gases to expand, resulting in an explosion.
- See the EHSO website and access the SDS database for more information on these substances.

10.5 Explosion Hazards

Inside the protective housing of some lasers or laser systems are arc lamps, filament lamps or other glass structures that are under high pressure. These structures have the possibility to explode during normal operation of the laser and must remain enclosed inside the protective housing.

11.0 Medical Surveillance

The control measures outlined in this document serve as guidelines for minimizing the exposure of personnel to Class 3B and Class 4 laser radiation in excess of the MPE limits. However, when this purpose has not been fulfilled, a method to assess the degree of injury must be in place. The rationale behind medical surveillance is to establish this method.

The following measures must be in place for medical surveillance as prescribed by ANSI Z136.1.

11.1 Post-Exposure Examinations

In the event of an injury, suspected injury, or exposure above the applicable MPE, personnel should seek medical examination as soon as possible (preferably within 48 hours). Information such as symptoms, the wavelength of the laser device, and the type of beam output (pulsed, continuous wave, or Q-switched) should be provided to the examiner.

11.2 Periodic Medical Examinations

Periodic medical examinations are not required by the ANSI Z136.1 standard.

12.0 Accident/Injury Reporting

In the event an accident or injury occurs during the operation of laser equipment (and/or when the injury is not related to the operation of the laser), refer to the Emergency tab of the EHSO website (www.ehso.emory.edu). A post exposure medical exam for eye function should be performed within 48 hours (if the injury is laser related).

- At Emory University:
  - Promptly report the incident to your immediate supervisor.
  - Seek medical attention at Occupational Injury Management (OIM) (between 7:30 am – 4 pm), or EUH ER after 4 p.m.
  - Report exposure in PeopleSoft (https://hrprod.emory.edu) as follows: Emory HR website > Self-Service > Workplace Health> HOME portal
- At Emory National Research Primate Center:
  - Report to the Environmental Health and Safety Office located at the 3rd floor RM 3147 or 2nd floor RM 2109
    Office: 404-727-8012
    Cell: 404-275-0963
- Additional information can be found at the Emory University Accident/Injury Reporting webpage.

13.0 References

- ANSI Z136.1; Safe Use of Lasers
- ANSI Z136.3; Safe Use of Lasers in Health Care
- Georgia Department of Community Health 111-8-91: Rules and Regulations for Laser Radiation

14.0 List of Associated Documents

- EHS-445, Laser Standard Operating Procedure
- EHS-449, Procedure Concerning Intra-Emory Laser Access and Usage

Appendix A: Summary of Laser Classification Schemes

Table A – Laser Classification Schemes

FDA/CDRH (21 CFR 1040.10)	ANSI Z136.1	IEC/EN 80625
Class I Levels of laser radiation are not considered hazardous.	**Class 1** No hazard; exempt from all control measures.	**Class 1** No risk, even with viewing instruments
N/A	**Class 1M** Not capable of producing hazards during normal operation unless beam is viewed with an optical instrument (e.g. eye loupe or telescope); exempt from control measures other than to prevent potentially hazardous optically aided viewing.	**Class 1M** No risk; possible risk to eyes when viewed through viewing instruments (eye loupes or binoculars.
Class II Levels of (visible only) laser radiation considered a chronic viewing hazard.	**Class 2** Visible (0.4-0.7 µm) lasers not considered hazardous for momentary viewing (<0.25 seconds), but for which the class 1 accessible emission limit may be exceeded for longer exposure durations; avoid prolonged staring.	**Class 2** No eye risk for short term exposures, even with viewing instruments; no risk to skin (applies to visible lasers only).
Class IIA Levels of laser radiation (applies to visible only) are not considered hazardous if viewed ≤ 1000 seconds but are considered a chronic viewing hazard for any period of time >1000 seconds.	**Class 2M** Emits in the visible region of the spectrum (0.4-0.7 µm); the aversion response is normally adequate protection during unaided viewing. Potentially hazardous if viewed with certain optical aids.	**Class 2M** No eye risk for short term exposures; possible with viewing instruments; no risk to skin (visible only)
Class IIIA Levels of laser radiation are considered, depending upon the irradiance, either an acute beam viewing hazard or chronic viewing hazard, and an acute viewing hazard if viewed directly with optical instruments.	**Class 3R** Potentially hazardous under some direct and specular reflection viewing conditions if the eye is focused and stable; probability of actual injury is small. Not a fire hazard; diffuse reflections not hazardous.	**Class 3R** Low risk to eyes, low risk to skin.
Class IIIB Levels of laser radiation are considered to be an acute hazard to the skin and eyes from direct radiation.	**Class 3B** Emit greater than Class 3R limits and pose an acute eye hazard; more rigorous controls are required to prevent exposure of the unprotected eye.	**Class 3B** Medium risk to eyes, low risk to skin.
Class IV Levels of laser radiation are considered an acute hazard to the skin and eyes from direct and scattered radiation.	**Class 4** Acute eye and skin hazard, plus ignition source (fire) and laser-generated airborne contaminants hazard; strict control measures required.	**Class 4** High risk to eyes and skin.

Appendix B: Laser Safety Program Differences for Emory University and Emory Healthcare

Table B – Differences between Emory University and Emory Healthcare

TERM	EMORY UNIVERSITY	EMORY HEALTHCARE
LSO	Director of Radiation Safety, Emory University	
DLSO	Assigned by LSO.	Assigned by LSO.
LSC	Principal Investigator or Core Lab Director.	Assigned by department.
Training for Laser Specialists and LSCs	General Laser Safety Training is available via the online platform, EHSA.	General Laser Safety Training is available via the online platform, HLC.
Certification and Credentialing	Not Applicable.	Not required: obtained and maintained by Laser Operator.
Laser Device Registration	Complete the Laser Device Registration online via EHSA within 30 days of receipt.	Complete the Laser Device Registration online via EHSA within 30 days of receipt.

Change History

Version 7
Updated roles and responsibilities for laser safety officer, deputy laser safety officers and laser safety contacts, laser safety specialists, and laser operators.
Updated table to distinguish differences in the program between Emory University and Emory Healthcare.
Corrected grammatical errors.
Updated with current regulation references.
Replaced BioRaft with EHSA.
Removed registration form requirement.
Updated table of contents.
Updated training requirements.

Version 6
Updated roles and responsibilities for laser safety officer, deputy laser safety officers and laser safety contacts, laser safety specialists, and laser operators.
Updated table to distinguish differences in the program between Emory University and Emory Healthcare.
Updated table of contents.
Added Laser Safety Specialist role.
Updated training requirements.

Version 5
Updated responsibilities for laser safety officer, deputy laser safety officers and laser safety site contacts, laser safety committee, and laser operators.
Updated class 3 laser hazards and controls.
Added information on classification of lasers built or modified on-site.
Added new definitions for terms.
Updated requirements for laser postings/signage.

Updated calculation of eye protection parameters section.
Added table to distinguish differences in the program between Emory University and Emory Healthcare.
Updated accident/incident reporting.
Removed requirement for baseline eye assessments.

Version 4 Document updated to new template - no content changes.

Version 3 In addition to changing the document title, clarifying verbiage, updating format and references throughout the document, these changes were made:

- Added ‘Laser Safety Committees’ section to the responsibilities heading.
- Changes to conditions for nominal hazard zone.

Version 2 Added equipment requirement under Class 4 Lasers heading.

Version 1 Document creation.