UNIVERSITY OF MINNESOTA
University Health and Safety

Laser Safety Program

Effective Date: February 2023

I. PURPOSE

The purpose of this program is to provide general laser safety information and to establish rules and procedures to ensure faculty, staff, students, and visitors are not exposed to laser radiation more than the Maximum Permissible Exposure (MPE) limit for the human eye or skin.

II. SCOPE

The Laser Safety Program applies to all employees, contractors, and students working directly with or around Class 3B or Class 4 lasers within University of Minnesota research laboratories, teaching labs, non-traditional research spaces (e.g. makerspaces), and machine shops.

III. DEFINITIONS

Accessible Laser Radiation – Laser radiation emitted that is compared with the Accessible Emission Limit to determine the hazard class of the laser.

ANSI – American National Standards Institute. This program is based on the American National Standard for Safe Use of Lasers (ANSI Z136.1-2014).

Aperture – An opening or window (in the laser protective housing) through which laser radiation passes.

Attenuation – Decrease in the radiant flux of any laser beam as it passes through a scattering or absorbing medium.

Authorized Personnel – Individuals who have been approved by the Principal Investigator or Lab Supervisor to install, operate and/or maintain laser(s) or laser system(s).

Aversion Response – An automatic, physical response by the body to avoid exposure to bright light. The typical response can manifest as: closure of the eyelid, eye movement, constriction of the pupil, or movement of the head. The aversion response is assumed to limit the exposure to bright (visible) light to less than 0.25 seconds.

Collecting Optics – Lenses or optical instruments capable of magnification therefore resulting in an increase in energy or power density. Examples include telescopes, binoculars, and microscopes.

Continuous Wave (CW) – A laser with a continuous output greater than 0.25 second is considered a CW laser.

Diffuse Reflection – Change of the spatial distribution of a beam of (laser) radiation when reflected in many directions by a surface or by a medium. This property can be wavelength dependent.

Embedded Laser – An enclosed laser that has a higher hazard classification than the laser system in which it is incorporated. The hazard class of the overall laser system is lower due to engineering features limiting (or eliminating) the level of accessible laser radiation.

Energy (Q) – The capacity for doing work. Commonly used to characterize the output from pulsed lasers, expressed in Joules (J).

Infrared Radiation (IR) – The region of the electromagnetic spectrum between the long-wavelength extreme of the visible spectrum (700 nm) and short-wavelength microwaves (1 mm).

Intra-beam Viewing – The viewing condition in which the eye is exposed to all or part of a laser beam (direct exposure or exposure from a specular reflection).

Laser Controlled Area (LCA) – A laser use area where occupancy and activity of personnel within are controlled and supervised. Within this area, potentially hazardous laser radiation exposure is possible. This area may be defined by walls, barriers, or other means. Please note this is not necessarily the same as a Nominal Hazard Zone (NHZ).

Laser System – An assembly of electrical, mechanical, and optical components that includes a laser.

Maintenance – Adjustments or procedures carried out by an authorized user to ensure intended performance of the product.

Maximum Permissible Exposure (MPE) – The level of laser radiation to which an unprotected person may be exposed without adverse biological changes (damage) to the eye or skin.

Nominal Hazard Zone (NHZ) – The space in which the level of direct, reflected, or scattered radiation (depending on hazard class) may exceed the applicable MPE. Any exposure beyond the determined boundaries of the NHZ does not exceed the applicable MPE.

Optical Density (OD) – A logarithmic expression used to determine the optical attenuation afforded by a material used in either laser eyewear or protective panels. $OD = \log_{10}(H_0/MPE)$

Permissible Exposure Limit (PEL) – The legal level of exposure to a hazard such as a chemical or physical (e.g., noise) agent in the workplace, as defined by OSHA.

Photochemical Effect – A biological effect caused by a chemical change due to absorption of photons (laser light).

Photokeratitis – a painful, temporary eye condition caused by exposure to ultraviolet (UV) light, similar to sunburn but affecting the corneas of the eyes instead of the skin.

Power (Φ) – The rate at which energy is emitted, transferred, or received. Commonly used to characterize the output from a CW laser or the average output of a pulsed laser. 1 W = 1 J/s

Protective Housing – An enclosure that surrounds a laser or laser system and prevents access to laser radiation above the applicable MPE. May consist of panels, partitions, or dividing walls (for example). The laser aperture is not part of the protective housing. Protective housing may also limit access to other components of the laser, including electrical hazards.

Pulsed Laser – A laser that delivers its energy in the form of a single pulse or a train of pulses. For this program, the duration of a pulse is less than 0.25 seconds.

Radiant Energy (Q) – Energy emitted, transferred, or received in the form of radiation.

Radiant Flux (Power) (Φ) – Power emitted, transferred, or received in the form of radiation.

Shall – The word *shall* is to be understood as mandatory.

Should – The word *should* is to be understood as advisory.

Specular Reflection – A mirror-like reflection.

Ultraviolet (UV) Radiation – Electromagnetic radiation with wavelengths between 180 nm and 400 nm.

Viewing Window – A visually transparent portion of an enclosure that allows for observation of the enclosed laser process.

Visible Radiation – Electromagnetic radiation with wavelengths between 400 nm and 700 nm.

IV. ROLES AND RESPONSIBILITIES

Laser Safety Officer (LSO):

- Develop, implement, and review the written laser safety program every two years.
- Conduct laser hazard analyses for Class 3B and Class 4 laser systems, including the establishment of Nominal Hazard Zones (NHZs) within a work area.

- Implement a laser safety training program.
- Provide guidance on design and implementation of laser systems, including appropriate personal protective equipment (PPE) and other controls.
- Periodically review and/or audit existing laser systems.
- Review Standard Operating Procedures (SOPs) developed for Class 3B and Class 4 laser systems.
- Investigate laser injuries or other incidents.
- Maintain a laser inventory of Class 3B and Class 4 lasers and laser systems.
- Advise on and approve the acquisition, transfer, or disposal of lasers.
- Organize and participate in a university-wide laser safety committee.

Principal Investigator (PI)/Laboratory Supervisor (LS):

- Ensure all members of the laboratory, whether working directly with lasers or not, complete all relevant laser safety training.
- Review SOPs associated with Class 3B or Class 4 laser systems in the lab and submit to the LSO for approval prior to use.
- Ensure visitors receive a site hazard orientation before allowing tours of laser areas while lasers are in use.
- Provide appropriate PPE to all laser users.
- Notify the LSO when new Class 3B or Class 4 lasers are to be acquired.
- Notify the LSO when modifications to previously approved laser control areas, or laboratory conditions in general, are made if these changes will impact safety.

Individual Users:

- Complete all required laser safety training.
- Obtain authorization from the PI before beginning laser work.
- Conduct laser experiments as laid out in the approved SOP.
- Follow all laser alignment procedures, including the proper use of PPE.
- Post or activate laser safety signage prior to beginning work.
- Report incidents to the PI/LS and LSO immediately, including laser malfunctions and accidental changes to optical configurations.
- Immediately report injuries or any suspected eye exposure to the PI and LSO.
- Seek out medical evaluation within 48 hours of a suspected exposure.

Laser Safety Committee:

- Comprised of representatives from several colleges and units within the University.
- Organized by the LSO but will be chaired by another member.
- Advise on new systems proposed by university laser users.
- Make recommendations for laser safety training programs and standard operating procedures.

- Facilitate compliance with laser safety standards within their respective colleges or units.
- Participate in the Laser Program review.

V. TRAINING REQUIREMENTS

Online Training

All users of Class 3B or Class 4 laser systems are required to complete the UHS online laser safety training module before beginning work with the laser. It is recommended that group members working around, but not actively with, Class 3B or Class 4 lasers complete the online training course as well.

Lab-Specific Training

Lab-specific laser safety training shall be provided to all employees, students, and volunteers routinely working with or potentially exposed to Class 3B or Class 4 laser radiation. Training should also be provided to anyone working with or potentially exposed to Class 1M, Class 2, Class 2M, or Class 3R laser radiation. Lab-specific training will be provided by the Principal Investigator and/or Lab Manager.

Lab-specific laser safety training shall be offered:

- Annually
- When new personnel join the group
- Whenever a new hazard is introduced into the laser control area or significant changes are made to the laser operation or configuration.

Training shall be documented with information including, but not limited to:

- Laser operation
- Alignment procedures
- Working around, but not with, laser systems
- Protocols for laser incidents (suspected eye or skin exposure, injury, fire, etc.)
- Signature of each employee and the date on which the training was offered

VI. BEAM HAZARDS (BIOLOGICAL EFFECTS)

The biological effects due to laser radiation exposure depend on several factors, including wavelength, power/energy, and exposure duration. Below is a table describing the biological effects to the eye and skin as a function of wavelength.

Wavelength Range	Effect(s) on the Eye	Effect(s) to the Skin
UV-C (180 nm – 280 nm)	• Photokeratitis • Cornea injury (thermal)	• Sunburn • Skin cancer
UV-B (280 nm – 315 nm)	• Photokeratitis • Cornea injury (thermal)	• Accelerated skin aging • Pigmentation increase
UV-A (315 nm – 400 nm)	• UV cataract • Anterior eye injury (thermal)	• Darkening of pigment • Skin burn
Visible (400 nm – 700 nm)	• Photochemical and thermal injury to retina • Photomechanical damage due to short pulses	• Photosensitive reactions • Skin burn
Infrared-A (700 nm – 1400 nm)	• Cataract • Thermal injury to retina • Photomechanical damage	• Skin burn
Infrared-B (1.4 µm – 3.0 µm)	• Burn to cornea • IR cataract • Anterior eye injury (thermal)	• Skin burn
Infrared-C (3.0 µm – 1000 µm)	• Burn to cornea	• Skin burn

The human eye, when suddenly exposed to bright light, has a built-in defense mechanism known as the ‘Aversion Response’, which is generally characterized by the closing of the eye or turning of the head to minimize exposure to the intense light. This response is assumed to occur within 0.25 seconds of visible light exposure (the response will not occur for UV or IR light). This response is generally sufficient to protect the eye from lower-power continuous-wave lasers but will not prevent injury due to higher-power lasers (greater than 5 mW) in which damage can occur in less than 0.25 seconds.

Reminder: Intra-beam (or direct beam) exposure can result in the most damage to the eye or skin. However, stray beams from unintended reflections account for the bulk of laser injuries.

VII. NON-BEAM HAZARDS

In addition to beam-related injuries to the eye and skin, lasers can also cause injuries not related to direct interaction with the emitted laser radiation. Some, but not all, of these hazards are described in this section.

Fire

Flammable or combustible materials placed in the beam path of a Class 4 laser can present a fire hazard. These materials must be placed outside of the Nominal Hazard Zone (NHZ) of all Class 4 lasers. Surfaces that may unintentionally reflect the beam should be painted with non-reflective paint to prevent stray beams from striking flammable or combustible materials. If using laser curtains as a control measure, ensure they are rated for the power/energy of the laser system used. Rooms containing Class 4 lasers must have fire extinguishers mounted near the exit of the room to allow for safe egress. Carbon dioxide (CO_2) extinguishers are recommended vs. dry chemical, which can damage optics.

Electrical

The use of any laser system can present an electric shock hazard. Many systems rely on large power supplies and higher than standard voltage to operate, creating a greater potential of electric shock. Exposure can occur during set up/installation, maintenance, or servicing when protective coverings are removed to allow access to active components. Working on equipment that is not properly grounded or with large capacitor banks that have not fully discharged can also lead to shock. When servicing or maintaining a laser system, follow Lockout/Tagout procedures before work begins.

Power cords or other cables, necessary for the operation of the laser system, should either be removed from the walkway (by utilizing drop-down outlets) or have covers placed over them to prevent trip/fall hazards and protect the cables from being stepped on or rolled over.

Chemicals

Some laser systems use dyes, organic compounds mixed with solvents, as a laser medium. These dyes are generally hazardous substances, and they must be handled with care. Laser systems may also incorporate hazardous gases such as chlorine or fluorine. Be sure to follow all safety protocols when storing and using compressed gases. Safety Data Sheets (SDSs) must be available to anyone working with these chemicals.

Air Contaminants

Laser Generated Air Contaminants (LGACs) can be produced when operating Class 3B or Class 4 lasers or laser systems, as well as Class 1 systems, such as laser cutters, with embedded Class 3B or Class 4 lasers. LGACs are created when the laser beam interacts with its target resulting in emissions of metallic fumes, dust, chemical vapors, or other contaminants. Adequate local or area ventilation must be utilized to keep these contaminants below Permissible Exposure Limits (PELs). Contact University Health and Safety to request an industrial hygienist determine if the contaminants generated pose a health hazard and if room ventilation is adequate for the desired use and placement of the laser or laser system.

In addition to LGACs produced from beam strikes on metallic or ceramic targets (for example), the use of lasers targeting biological tissues in medical or biological research may result in the aerosolization of the contents of the target cells. These aerosols may be either chemical or biological in nature. Biological LGACs may be viral or bacterial and exposure may lead to human infection. Adequate local ventilation must be employed to eliminate exposure to these chemical or biological aerosols.

Sharps

When fiber optic cables are cut or broken, they may develop sharp or jagged edges and can easily cause a cut or puncture to the skin. Care must be taken when handling broken fibers or cuttings that have fallen onto the benchtop or floor by sweeping with a broom or a piece of cardboard (never pick up broken fibers with your hands). Care must also be taken when handling cracked or broken glass optics, such as lenses or mirrors. Dispose of any sharp in an appropriate sharps container and not in the lab trash can.

VIII. CONTROL MEASURES

Control measures for lasers are generally divided into three groups: engineering, administrative, and PPE. These are part of the Hierarchy of Controls, where engineering controls, which are the most reliable of the three, should be implemented first and PPE is considered the last line of defense.

Engineering Controls

The following table summarizes engineering controls that may or may not be required for laser operation, depending on the class of laser in use.

Engineering Control Measures	Laser Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing[1]	X	X	X	X	X	X	X
Without Protective Housing[2]	Contact LSO to determine alternative controls						
Interlocks on Removable Protective Housings[3]	Δ	Δ	Δ	Δ	Δ	X	X
Service Access Panel[4]	Δ	Δ	Δ	Δ	Δ	X	X
Key Control[5]	-	-	-	-	-	O	O
Viewing Windows or Display Screens[6]	Viewing exposure < MPE						
Collecting Optics[7]	X	X	X	X	X	X	X
Fully Open Beam Path[8]	-	-	-	-	-	X NHZ	X NHZ
Limited Open Beam Path[9]	-	-	-	-	-	X NHZ	X NHZ
Fully Enclosed Beam Path[10]	Further controls not required if 1 and 3 are fulfilled						
Area Warning Device[11]	-	-	-	-	-	O	X
Laser Radiation Emission Warning[12]	-	-	-	-	-	O	X
Entryway Controls[13]	-	-	-	-	-	-	X
Protective Barriers and Curtains	-	-	-	-	-	-	O

Key:
X *Shall (Required)*
O *Should (Recommended)*
- *No Requirement*
Δ *Shall if enclosed Class 3B or Class 4*
NHZ *Nominal Hazard Zone analysis required by LSO*

1. **Protective Housing** – An enclosure that surrounds the laser or laser system that prevents access to laser radiation above the applicable MPE. Also limits access to other hazards associated with laser operation, including electrical hazards (components and terminals).

2. **Without Protective Housing** – If a laser is operated without its protective housing, the LSO shall perform a hazard analysis to determine alternative engineering controls to

implement. These controls may include, but are not limited to barriers, shrouds, conduits, and beam stops.

3. **Interlocks on Removable Protective Housing –** An interlock or interlock system will, by design, prevent access to laser radiation above the applicable MPE in the event the protective housing enclosing a Class 3B or Class 4 laser is opened or removed during operation.

4. **Service Access Panel** – A portion of the protective housing intended to be accessed only by qualified service personnel. Interlocks may be defeated, allowing for direct access to Class 3B or Class 4 laser radiation. Appropriate warning labels shall be located on the protective housing indicating the level of laser hazard located within the housing.

5. **Key Control** – Class 3B or Class 4 laser or laser systems should be provided with a master switch. This master switch must terminate the beam and/or prompt a system shutoff and shall be operated by key or coded access.

6. **Viewing Windows or Display Screens** – All viewing windows and diffuse display screens included as part of a laser or laser system shall maintain the laser radiation at the viewing position at or below the applicable MPE, as determined by the LSO. This may be accomplished using interlocks, filters, or attenuators. Any viewports and films not part of the original manufacturer construction should be labeled with the optical density (OD) and spectral region (wavelength) for which protection is afforded.

7. **Collecting Optics** – Collecting optics such as lenses, telescopes, and microscopes shall incorporate suitable means, such as interlocks, filters, and attenuators to maintain laser radiation transmitted through the optics to levels at or below the applicable MPE, as determined by the LSO.

8. **Fully Open Beam Path** – Class 3B or Class 4 lasers or laser systems with a totally unenclosed beam path must have a laser hazard analysis performed by the LSO.

9. **Limited Open Beam Path** – The LSO shall perform a hazard analysis for Class 3B or Class 4 lasers or laser systems with a beam path confined in such a manner as to significantly limit the degree of accessibility of the open beam. This analysis will be limited to the area(s) where laser radiation is accessible at levels above the MPE.

10. **Fully Enclosed Beam Path** – Class 3B or Class 4 lasers or laser systems that are completely enclosed fulfill requirements for protective housing are considered as meeting the requirements for Class 1 laser systems and no further engineering controls are required.

11. **Area Warning Device** – A Class 3B laser controlled area should have and a Class 4 laser controlled area must have an area warning device. This warning device should be visible prior to entering the area and be visible through laser safety eyewear and in limited light conditions. Warning devices may be mechanical or electrical in nature and indicate when

the laser is operating. An example of an area warning device is a lighted ‘Laser in Use’ sign near the entry to a laser lab.

12. **Laser Radiation Emission Warning** – Within the laser controlled area, an audible or visible warning device should be used with Class 3B lasers or laser systems and must be used with Class 4 lasers or laser systems. The most common emission warning device is a single light located on the laser or control panel. If the warning device is a light, it should be the color red.

13. **Entryway Controls** – Class 4 laser controlled areas shall incorporate one of the following:
    i. Non-defeatable safety latches, entryway, or area interlocks
    ii. Defeatable safety latches, entryway, or area interlocks in the case that non-defeatable would limit the intended use of the laser system. LSO will perform analysis to ensure there is no laser radiation hazard at the point of entry.
    iii. Procedural area or entry safety controls including adequate training of all personnel or doors, barriers, or curtains to block or attenuate laser radiation at the entryway.

Additional Engineering Control Considerations

i. Laser beams should be maintained at a level other than the normal position of the eye of a person either standing or sitting. Pay close attention to locations in the lab other than the immediate area of the laser or laser system.
ii. Do not direct laser beam toward doors, windows, aisles, or other openings.
iii. All components of the laser systems must be secured to prevent accidental misalignment due to bumps or other disturbances to the system.

Administrative Controls

The following table summarizes administrative controls, including procedural controls, required for laser operation depending on the class of laser.

Administrative Control Measures	Laser Classification						
	1	1M	2	2M	3R	3B	4
Standard Operating Procudures[1]	-	-	-	-	-	O	X
Output Emission Limitations[2]	-	-	-	-	Consult LSO		
Training[3]	-	O	O	O	O	X	X
Authorized Personnel[4]	-	-	-	-	-	X	X
Indoor Laser Controlled Area[5]	-	-	-	-	-	X NHZ	X NHZ
Class 4 Laser Controlled Area[6]	-	-	-	-	-	-	X
Temporary Laser Controlled Area[7]	Δ MPE	Δ MPE	Δ MPE	Δ MPE	Δ MPE	-	-
Controlled Operation[8]	-	-	-	-	-	-	O
Alignment Procedures[9]	Δ	X	X	X	X	X	X
Spectators[10]	-	*	-	*	-	O	X
Outdoor Control Measures[11]	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Service Personnel	Consult LSO						

Key:

X	*Shall (Required)*
O	*Should (Recommended)*
-	*No Requirement*
Δ	*Shall if enclosed Class 3B or Class 4*
NHZ	*Nominal Hazard Zone analysis required by LSO*
MPE	*Shall if MPE is exceeded*
***	*May apply with use of optical aids*

1. **Standard Operating Procedures (SOPs)** – Written standard operating, maintenance and service procedures should be reviewed and approved by the LSO for Class 3B lasers or laser systems and shall be reviewed and approved for Class 4 lasers or laser systems.

2. **Output Emission Limitations** – If the LSO determines there is excessive power or radiant energy accessible during operation, maintenance, or service of a Class 3B or Class 4 laser or laser system, the LSO will act such that the accessible power or radiant energy is reduced to a level that is appropriate for the required application.

3. **Training** – Training shall be provided for operators of Class 3B and Class 4 lasers or laser systems. Personnel working in the laser controlled area, but not directly interacting with the laser or laser system shall also be provided with training (refer to the TRAINING REQUIREMENTS section).

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

5. **Indoor Laser Controlled Area** – The LSO shall perform a hazard analysis for all Class 3B or Class 4 lasers and for any systems of lower hazard class containing a Class 3B or Class 4 laser. If it is determined that the maximum level of accessible radiation is Class 3B or Class 4, a laser controlled area shall be established, and appropriate control measures implemented.

6. **Class 4 Laser Controlled Area** – Class 4 laser area or entryway controls shall be designed to always allow for both rapid egress by personnel and admittance into the area under emergency conditions.

7. **Temporary Laser Controlled Area** – In the event where panels or protective housings are removed, overriding of protective interlocks, or entry into the Nominal Hazard Zone (NHZ) is required, laser service for example, and the accessible radiation exceeds the MPE, a temporary laser controlled area shall be created. This area will meet the requirements for Class 3B or Class 4 laser controlled areas.

8. **Controlled Operation** – Whenever appropriate and possible, Class 4 lasers or laser systems should be operated and monitored from a position as far as possible from the emission portal of the laser or laser system.

9. **Alignment Procedures** – Perform alignment of Class 3B or Class 4 laser optical systems in such a way that prevents exposure exceeding the applicable MPE. See Appendix B for Alignment Guidelines.

10. **Spectators** – Spectators should not be allowed to enter a laser controlled area that contains a Class 3B laser or laser system and spectators shall not be allowed to enter a laser controlled area that contains a Class 4 laser or laser system unless:
    i. Approval from the Principal Investigator or area manager has been obtained
    ii. The spectators have received basic training on the hazards present
    iii. Appropriate protective measures have been implemented

11. **Outdoor Control Measures** – The following is a list of some of the additional administrative controls required for Class 3B and Class 4 lasers or laser systems used outdoors:
    i. The LSO shall effect a laser hazard analysis to establish the NHZ.
    ii. The NHZ shall be clearly posted with laser warning signs.
    iii. All personnel authorized to enter the NHZ shall be appropriately trained.
    iv. Only authorized personnel shall operate the laser or laser system.
    v. Appropriate combinations of barriers, screening, and PPE shall be provided to and be used by personnel within the NHZ.
    vi. Directing the laser beam toward automobiles, aircraft, or other inhabited structures or vehicles shall be prohibited unless adequate training and PPE is provided, or as authorized by the LSO.
    vii. The exposed laser beam path shall not be kept at or near eye level without authorization from the LSO.
    viii. The beam path must be confined and terminated wherever possible.
    ix. The laser or laser system, when not in use, shall be disabled in such a way as to prevent unauthorized use.

x. The use of Class 4 lasers or laser systems during rain, snow, fog, or dusty atmosphere may produce hazardous scattering in the vicinity of the beam. In such conditions, the LSO must be consulted on the need and use of appropriate PPE.
xi. If visible lasers are used at night, the LSO will need to determine if such use will interfere with critical tasks.

Additional Administrative Control Considerations

i. Do not wear reflective jewelry such as metallic rings or watches while working near the beam path. This is most important during alignment procedures.
ii. Remove unnecessary items from the optics table or other laser work areas (to reduce the possibility of unwanted reflections or fire).

Personal Protective Equipment (PPE)

The following table summarizes Personal Protective Equipment (PPE) that may or may not be required for laser operation, depending on the class of laser in use.

Personal Protective Equipment	Laser Classification						
	1	1M	2	2M	3R	3B	4
Laser Eye Protection[1]	-	-	-	-	-	X	X
Protective Clothing[2]	-	-	-	-	-	O	O
Skin Protection[3]	-	-	-	-	-	O	O

Key:
X *Shall (Required)*
O *Should (Recommended)*
- *No Requirement*

1. **Laser Eye Protection** – Laser eye protection (LEP) shall be provided to all personnel operating Class 3B or Class 4 lasers or laser systems. LEP may include goggles, face shields, or glasses and will consist of special absorptive filter materials and/or reflective coatings. The LEP must be of the correct optical density (OD), which will be determined by the LSO, and wavelength range.
   - Certain eye protection materials may not be effective against direct strikes from ultra-fast (femtosecond) pulsed lasers with high peak energy. Please consult with the manufacturer/supplier to determine the proper eye protection in this case.

2. **Protective Clothing** – Skin protection is best achieved through engineering controls preventing skin exposure all together. If engineering controls cannot eliminate potential exposure, a laboratory jacket or coat, in conjunction with gloves, may fulfill the requirement. If working with Class 4 lasers or laser systems, and there is the potential for skin exposure, consider using flame-resistant fabrics such as Nomex.

3. **UV Skin Protection** – Repeated or prolonged skin exposure to UV laser radiation may result in occurrences of sunburn, accelerated skin aging, or possibly skin cancer. In addition to protective clothing, sunscreen may be recommended for exposed skin.

However, be aware that sunscreen is only effective against exposure to certain (not all) UV wavelengths.

Additional PPE – As a temporary control measure, respirators and other PPE shall be required whenever engineering controls are unable to offer sufficient protection from laser generated air contaminants (LGACs) or other hazards.

IX. CONTROLLED AREAS

The purpose of laser controlled areas is to confine laser hazards from an open-beam configuration to a well-defined space that is under control of the laser user(s). The intent is to prevent injury to visitors or others working near the controlled area.

Class 3B Controlled Areas

Laser controlled areas containing Class 3B lasers shall have the following control measures:

1. **Authorization** – Only personnel who have been authorized by the responsible Principal Investigator may operate the laser. The PI may only give authorization to personnel who have completed the required training. Personnel who require access to the laser controlled area but will not be operating the laser or laser system, must also complete lab-specific training.

2. **Signage** – The laser controlled area must be posted with appropriate “Warning” signs indicating the nature of the hazard, to include wavelength, power/energy, and required PPE. Signage must conform to the ANSI Z136.1 guidelines (see Appendix D). Generally, signage is posted on the exterior door to a lab, even if the controlled area is only a portion of the lab.

3. **Eye Protection** – Appropriate laser eyewear with the correct optical density and wavelength range shall be provided to all personnel entering the laser controlled area. Protective eyewear must always be worn while the laser is operating.

4. **Laser Light Containment** – Any laser radiation beyond the calculated MPE must not pass the boundaries of the laser controlled area. All windows, doors, and other openings must be covered if there is the possibility of laser radiation escaping from the controlled area.

5. **Beam Stops** – Laser beams must be terminated at the end of their useful paths. Beam stops must consist of a material that is non-reflective, fire resistant, and can adequately absorb and dissipate the beam power as waste heat.

Class 4 Controlled Areas
In addition to the controls listed in the Class 3B Controlled Area section, the following controls will be implemented for Class 4 Controlled Areas:

1. **Rapid Egress and Emergency Access** – Rapid egress provisions must be provided for Class 4 laser controlled areas under all normal or emergency situations. Interlock systems must not interfere with emergency egress. In addition, control measures must not interfere with the ability of emergency responders to enter the area if personnel become injured or incapacitated.

2. **Key Access** – Class 4 lasers must have a master activation switch that is controlled by a key or code. Only trained *and* authorized personnel may have access to the key or code.

3. **Laser Activation Warning System** – A visible or audible warning sign or signal shall be located at the entrance to the laser controlled area and may be either electrical or mechanical. The warning system will indicate when the laser is energized and operating.

4. **Entryway Controls** – The PI shall implement one of the following entryway control measures for all Class 4 laser controlled areas:
    i. Non-defeatable entryway controls such as latches or interlocks to deactivate or reduce the output levels of the laser to below the calculated MPE in the event of unauthorized entry into the control area.
    ii. Defeatable entryway controls (latches or interlocks) shall be used if the controls previous listed will adversely affect the intended use of the laser or laser system (such as extended runtime experiments). If there is no laser light hazard at the point of entry, the interlock may be bypassed to allow access by authorized personnel.
    iii. Administrative *and* Engineering Controls – Authorized personnel having completed the required training and wearing the appropriate PPE may enter the controlled area. In addition, a secondary barrier, such as a laser curtain, shall be used to block all laser radiation at the point of entry. Finally, a visible or audible warning indicating the laser is in operation shall be utilized. Existing installed warning signs or lights will satisfy this requirement.

X. STANDARD OPERATING PROCEDURES (SOPs)

As with any experimental procedure or other hazard, an SOP should be developed when introducing a new laser or laser system to the lab, or when significantly modifying an existing procedure or configuration. This section will detail the information that should be included in your lab's laser SOP(s) (see Appendix C for a sample SOP).

1. Introduction
The introduction should include the following information:
- Manufacturer, serial number, and model number
- Type (CW or Pulsed)

- Classification (Class 3B or Class 4)
- Lasing medium (gas, semiconductor, dye)
- Location of laser (building, room number)
- Technical specifications including wavelength, power/energy, pulse length, repetition rate, beam diameter and divergence

Briefly describe the purpose of the experiment.

2. Hazards

Identify the specific hazards associated with the laser operation, including the following:

- Electrical
- Fire
- Hazardous chemicals
- Laser generated air contaminants
- Trip hazards
- High pressure
- Cryogens
- Others

3. Hazard Controls

Once the above hazards are identified, detail how they will be mitigated. List the controls required to accomplish this, including:

- Door interlocks
- Training
- Protective eyewear
- Signage
- Barriers and/or curtains

Refer to the CONTROL MEASURES section for an extensive list of engineering, administrative, and PPE controls.

4. Operating Procedures

Describe the complete operation of the laser system, including when specific safety controls are implemented. The procedure(s) should be written specifically for the laser user(s), not necessarily for the benefit of others in the lab. An exception to this would be emergency procedures and response.

5. Alignment Procedures

Alignment procedures should be documented as described in Appendix B. This should be a separate document to the general laser SOP.

6. Training

Describe the training requirements for all laser users as well as lab members not directly interacting with the laser system. Laser users are required to complete both the UHS on-line training module and lab-specific training. Other lab members require lab-specific training and should (but are not required to) complete the on-line training.

7. Emergency Procedures
Describe what actions will be taken in the event of an injury, fire, suspected laser exposure, or other emergencies. Include names and contact details for:

- Principal Investigator and Lab Supervisor
- University Laser Safety Officer
- University Police and Fire
- Department Safety Officer

XI. INJURIES AND MEDICAL EVALUATION

Most laser injuries occur during the process of alignment. When carrying out alignment procedures, please refer to the alignment guidelines laid out in Appendix B.

Reporting Procedures
In the event of any accident or suspected exposure to laser radiation, report the incident to the PI and/or Lab Supervisor immediately. In the event of serious injury, illness, or fire, call 911.

All incidents involving lasers must be reported to the Laser Safety Officer by the PI, or someone designated by the PI, within 48 hours. If the injury requires hospitalization, you must inform the Laser Safety Officer immediately so the injury can be reported to OSHA.

Medical Evaluation
Eye exams must be performed after an actual or suspected injury caused by a laser. Evaluations should take place as soon as possible, no longer than 48 hours after the suspected exposure.

For laser-induced injuries to the retina from visible and NIR exposure, the examination shall be performed by an ophthalmologist. Employees with laser-induced skin injuries should be seen by a physician.

Incident Investigation
In the event of a laser-induced injury or suspected exposure, the PI or Lab Supervisor should complete a First Report of Injury form within one business day of the incident. After this form is submitted, both the LSO and a representative from University Health and Safety (UHS) will contact the PI (or Lab Supervisor), as well as the employee, and initiate an investigation. Steps in the investigation may include:

a. LSO interviews injured worker(s) and witness(es)
b. LSO examines the work area for any factors that may have contributed to the incident
c. LSO determines possible causes of the incident
d. LSO recommends corrective actions for the PI and/or Lab Supervisor to implement to avoid future incidents
e. Findings and corrective actions are documented and maintained by the PI and made available to the LSO upon request.

APPENDIX A: LASER ACQUSITION, TRANSFER, AND DISPOSAL

Before a Class 3B or Class 4 laser or laser system is acquired, transferred, or disposed of, approval from the Laser Safety Officer is required. Please review the guidelines and requirements below for each instance.

Laser Acquisition

Prior to purchasing or receiving a Class 3B or Class 4 laser or laser system, the LSO should be informed. The specifications of the laser, the location in which it will be installed, a list of authorized laser users, and the purpose of the experiment should all be included in the communication with the LSO. The laser or laser system can be purchased once approved by the LSO. After the laser has been acquired, it should be entered into the University's Laser Inventory System (contact the LSO for instructions).

Laser Transfer

Internal Transfers or Sales

1. Internal transfers require review and approval by the LSO before transfer.
2. Transfers can only be made if the laser is in good working order and complies with all applicable safety standards.
3. To request a transfer, inform the LSO of the following
    i. Name and contact information of PI transferring the laser/laser system
    ii. The current location of the laser
    iii. Laser specifications
    iv. Name and contact information of PI receiving laser
    v. New location of the laser
4. The University Laser Inventory will be updated with the new information once the transfer is approved by the LSO.

External Transfers or Sales

1. When planning to transport or ship a laser to a location outside of the University of Minnesota system, the LSO must be informed so they can assist with the determination of proper shipping conditions.
2. The LSO will provide guidance and approval, but the laboratory is responsible for all costs associated with shipping the laser or laser system.
3. Prior to shipping the laser, the LSO must be provided with the following:
    i. Laser to be shipped
    ii. Anticipated transfer date
    iii. Names of person(s) shipping and receiving the laser
    iv. The sending and receiving locations
    v. Contact information of those responsible
4. If significant modifications have been made to the laser, approval from the FDA may be required
5. Refer to the Capital Equipment Administration: Transfers policy when transferring lasers or laser systems considered to be capital equipment (over $5,000).

Laser Disposal

Plans for disposing of a laser should be discussed with the LSO, who may be able to offer alternative methods of disposal, depending on the condition of the laser. There are two preferred methods for disposing of an unwanted laser: returning it to the manufacturer or disposing of it as e-waste. In either case, please refer to the Capital Equipment Disposals: Scrap, Recycle or Cannibalize policy on disposing of capital equipment (over $5,000).

Return to Laser Manufacturer

1. Some manufacturers will accept old lasers for recycling value or to salvage parts for other users.
2. Contact the manufacturer to determine if the laser system can be returned for disposal, refurbishment, or recycling.
3. Notify the LSO of such a transfer and request the laser be removed from the University Laser Inventory.

Dispose of as e-Waste

1. Prior to disposal, review the manufacturer's user manual for a list of hazardous materials or components that may be contained within the laser.
2. If the laser does contain hazardous materials (dyes and solvents, oils, mercury switches, batteries, or other chemicals), remove the hazardous materials and submit a request for disposal through the Chematix Inventory and Waste system.
3. Disable the device by cutting off the plug or power cord or removing all means of activating the laser.
4. Contact UHS and request an inspection of the laser to confirm all hazardous materials have been removed.
5. Dispose of it through your campus' e-waste program.
6. Notify the LSO that the laser system will be disposed of and should be removed from the University Laser Inventory.

DO NOT send unwanted lasers to the ReUse Facility. Doing so will make it impossible to determine the final destination of the laser and whether the end user is properly trained in its operation.

APPENDIX B: ALIGNMENT GUIDELINES

Laser injuries (from Class 3B or Class 4 lasers) in the research lab are most likely to occur during the alignment process. It is during this process that optical elements are manipulated while the laser is active. Injuries occur when there is an unexpected reflection off an optical element and the researcher is not wearing the proper protective eyewear (to see their work without a reduction in light transmission). The following are guidelines to observe before and during the alignment process.

1. Develop a Standard Operating Procedure (SOP) and review this document with the LSO (required for Class 4 lasers or laser systems) and PI.
2. Minimize the number of people involved in the alignment process.

3. Identify the equipment and materials necessary to perform alignments safely.
    i. Whenever possible, view beams indirectly using thermal paper, viewing scopes, or phosphor-viewing cards. Make sure all surfaces are matte or diffusing surfaces.
    ii. Tools (non-reflective surfaces), beam blocks/stops, power meters, curtains, signage
    iii. PPE such as alignment eyewear, face shields for scattered UV, skin protection as necessary.
4. Ensure the immediate work area/bench/optical table is free of mirror-like reflectors not needed for alignment
5. Remove all metallic rings or watches that may be reflectors or electrically conductive. If a piece of jewelry is not easily removed, cover with several layers of electrical tape. Remove or secure loose articles of clothing (e.g., neckties, headscarves, etc.) that may drop into the beam path.
6. Isolate the area and minimize the hazard to others.
    i. For Class 4 open-beam systems, ensure exterior warning signs are posted
    ii. Confine the beam to the optical table or benchtop. Use viewers or cards to locate the beam at all locations on the table.
    iii. If multiple lasers are located on the same table or adjacent tables, physically isolate with a barrier curtain.
7. If the primary laser is pumped by another laser, and alignment between the two is required, block the primary beam (utilizing the shutter or a beam block) to limit potential multi-wavelength exposure. Be sure to replace the beam enclosure in the pump-to-laser path.
8. If the beam path to be aligned is in multiple rooms (i.e., there is a portal in a dividing wall through which the beam travels), block the path between rooms and perform required alignments in the primary room. After the first alignment step is completed, remove the beam block and complete the alignment procedure. If multiple people are participating in the alignment process, and line of sight is blocked by the intervening wall, be sure to have some form of real-time two-way communication.
9. Use the lowest beam power/energy level possible or utilize a low-power coaxial laser beam for path simulation
    i. For CW lasers with adjustable power, set to a minimum stable level
    ii. For pulsed lasers, use single pulses and/or reduce pump power
    iii. In some cases, power-reducing filters, such as neutral density (ND) filters, may be used during the alignment process
    iv. Ensure you have protective eyewear with the appropriate optical density (OD) for the beam power used. Using high OD eyewear, generally used for normal operations, should not be used during alignment as this may cause the beam to not be visible. Conversely, alignment eyewear must never be worn during normal operation as there may not be sufficient protection from high-power beams
10. When performing the actual alignment:
    i. Never view beams directly, unless specifically approved by the LSO
    ii. Perform initial (rough) alignments with the beam blocked
    iii. As you move along the optical path, place beam blocks behind the optics to be adjusted

iv. When using aides to visualize the beam (viewing cards for example), reach into the beam path slowly and angle the card slightly away from you

v. If the beam changes elevation (using a periscope, for instance), be aware of the increased potential for vertical reflections

vi. Close the laser shutter or insert a beam block during any adjustments. Be sure all optical components are properly secured after adjustments are completed

vii. Be mindful of potential (unwanted) reflections from optical components including polarizers and dielectric mirrors. Always check for stray beams at each step of the alignment process and at the end of the process.

viii. If the alignment was performed with the laser at a reduced power level, or with a low-power coaxial laser, be sure to change to the appropriate eyewear for the high-power beam.

11. When the alignment process is complete and the system is ready for regular operations, restore all protective housings, beam tubes, and interlock switches and verify normal operation.

APPENDIX C: **SAMPLE SOP** (Editable Word document available here)

Laser Standard Operating Procedure for (name of lab).

This procedure is to be reviewed and signed annually by all members using the laser listed in this SOP. It is recommended that non-laser users review sections of this SOP, particularly Emergency Procedures.

Building and Room #:
Date:
Reviewed by PI:
Approved by LSO:

Personnel:

Principal Investigator		
Lab Safety Officer/Supervisor		
Laser User		
Laser User		
Laser User		
University Laser Safety Officer	Brian Andersson	lso@umn.edu

I. Introduction

Laser Information

Manufacturer:	Serial #:
Model #:	Type (CW or Pulsed):
Classification:	Lasing Medium:
Location:	Wavelength(s):
Power/Energy:	Pulse Length:
Repetition Rate:	Beam Diameter ($1/e^2$)

(Briefly describe the purpose of laser experiment here.)

II. Hazards and Controls

Indicate controls used to mitigate beam hazards.

_____ Door Interlocks
_____ Barriers and/or Curtains
_____ Signage
_____ PPE
_____ Beam Stops
_____ Viewing Devices
_____ Operating Key
_____ Other

In addition to hazards associated with direct beam exposure (intra-beam or reflections), non-beam hazards must be identified and addressed. Indicate in the table below the specific non-beam hazards associated with your laser system and the controls used to mitigate these hazards.

Y/N	Hazard	Control Measure(s)
	Electrical	
	Fire	
	Hazardous Chemicals	
	LGAC	
	Trip Hazards	
	High Pressure	
	Cryogens	
	Other	

III. Personal Protective Equipment

Laser Eyewear

Laser In Use			Required Eyewear		
Class	Type	Wavelength(s)	Manufacturer	Optical Density	Comments

Additional PPE Required While in Nominal Hazard Zone

Equipment	Location	Comment

IV. Operating Procedures
In this section, please detail how the laser or laser system will be operated, including, but not limited to:

- Pre-activation sequence (warning lights/signs, notifying non-laser users, barriers, etc.)
- Activation sequence
- Sequence of operations for experiment
- Methods of beam visualization (if applicable)
- Beam deactivation and post-experiment procedures (signage, etc.)
- Emergency shut-down procedures

(Insert detailed operating steps here)

V. Training
In the table below, list all personnel in the lab, whether they are a laser user, and the level of laser safety training received.

Name	Laser User? (Y/N)	Training (online, lab-specific) and Date

VI. Emergency Procedures
Describe what action will be taken in the event of a suspected laser exposure, injury, fire, or other emergencies (see Section 9 for guidance). Include names and contact details for:

- Principal Investigator and Lab Supervisor
- University Laser Safety Officer
- University Police and Fire
- Department Safety Officer

After lab personnel have reviewed the SOP, please sign and date below.

Name	Signature	Date

APPENDIX D: <u>SIGNAGE</u>

Areas in which Class 3B or Class 4 lasers or laser systems are used must post signage warning people of the potential hazards. It is the responsibility of the laboratory to acquire and maintain proper signage. At a minimum, the sign layout and wording must detail the highest-class laser contained within the area. Additional signs for lower-class lasers may also be displayed. These signs must comply with ANSI Z535 series (e.g., ANSI Z535.2: Environmental and Facility Safety Signs) and *ANSI Z136.1, Safe Use of Lasers.* Examples of laser warning signs are shown below.

Fig. 1. Laser sign for Class 4 lasers (multi-kilowatt). Reserved for lasers that may inflict severe or fatal injuries if bodily exposure occurs.

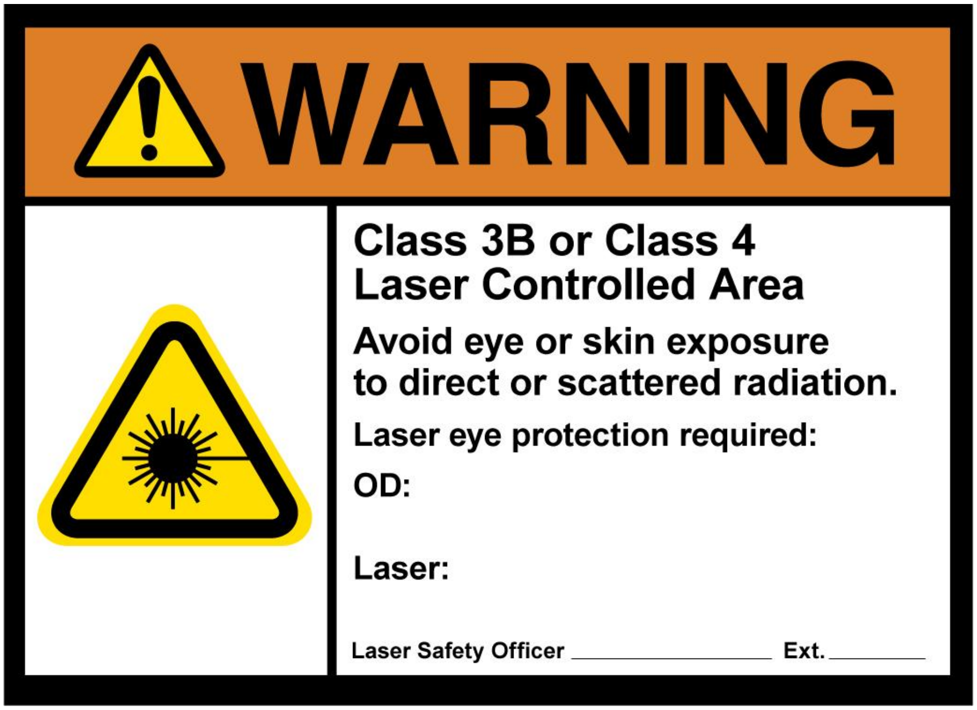

Fig. 2. Laser sign for Class 3B and Class 4 (below 1 kW) lasers.

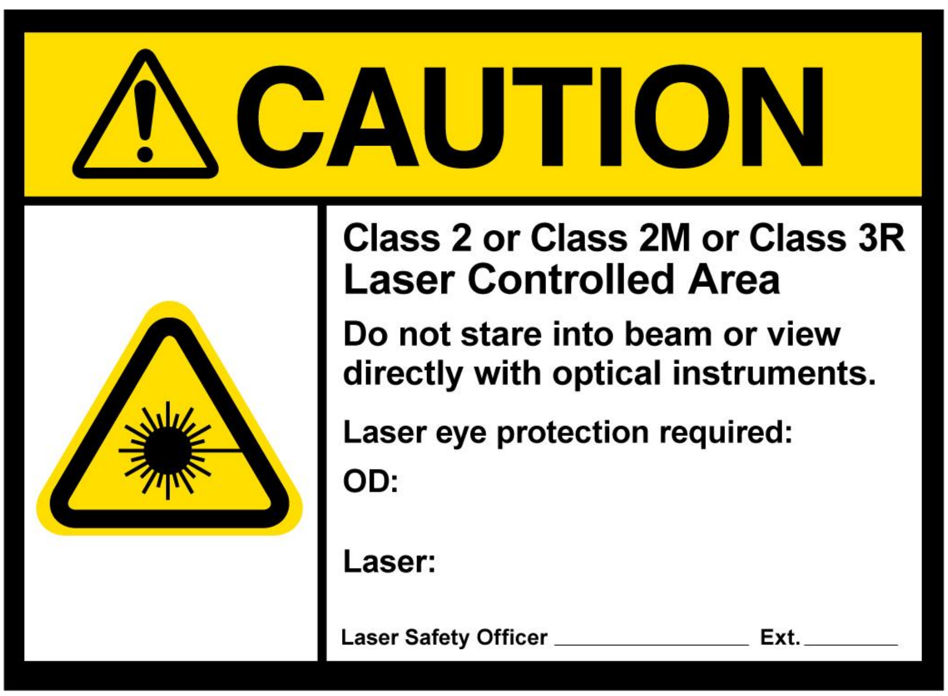

Fig. 3. Recommended (but not required) for areas containing Class 2, 2M or 3R lasers or laser systems.

Fig. 4. Signage used when a laser or laser system is undergoing maintenance. Often displayed when a normally enclosed laser system is undergoing repair or maintenance and safety interlocks, protective panels, etc. are removed allowing for the possibility of laser radiation exposure.

Fig 5. Example of a lighted sign operated either manually or automatically when a laser system is activated.

APPENDIX E: INSPECTION REQUIREMENTS

Periodic audits of lasers, laser systems, and/or associated optical systems are useful for identifying any deficiencies in a lab's laser setup and can provide focus areas for laser safety improvements. Inspections should also be conducted when changes to experimental operations are made. Below are items that should be reviewed by the PI and/or LS. These items will also be checked by the Laser Safety Officer during any scheduled inspections.

Signs and Labeling	Yes	No	N/A
1. Are all lasers, laser systems, and Laser Control Areas (LCA) properly labeled?			
2. Do signs contain appropriate information (class of laser, power, wavelength, required PPE)?			
3. Are all signs and labels in good condition and legible?			
4. Do signs conform to ANIS Z136.1 and ANSI Z535 standards?			
Training and Documentation			
1. Have all laser users completed the UHS on-line laser safety module?			
2. Have all personnel completed annual lab-specific laser training? Documented?			
3. Has your lab-specific training program been reviewed by the Laser Safety Officer?			
4. Have all laser accidents, incidents, or near misses been documented?			
Communication			
1. Is the Laser Safety Officer consulted prior to purchasing, transferring, or disposing of lasers or laser systems?			
2. Is your laser inventory up to date?			
Hazard Analysis Documentation			
1. Has a hazard analysis been conducted for each laser or laser system and documented?			
2. Does this documentation address both beam and non-beam hazards?			
Standard Operating Procedures (SOPs)			
1. Have SOPs been developed detailing the safe use of lasers or laser systems?			
2. Have alignment procedures been developed and documented?			
3. Has the Laser Safety Officer reviewed and approved all SOPs?			
4. Are all authorized users listed in the SOPs?			
Personal Protective Equipment			
1. For Class 3B and Class 4 lasers and laser systems, are laser safety glasses available for all personnel?			
2. Is laser eyewear of the correct OD, wavelength, and visible light transmission?			
3. For IR or UV lasers or laser systems, is additional protective clothing and other skin protection available?			
Safety Controls			
1. Are windows and ports covered to prevent a stray beam from entering an uncontrolled area?			
2. Are barriers/screens rated for the power/energy of the laser?			
3. Are all protective housings intact and interlocks tested?			

APPENDIX F: <u>LASER CLASSIFICATIONS</u>

Laser classifications are based on several parameters associated with any given laser, including:

- Laser output energy (Joules) or power (Watts)
- Radiation wavelengths
- Exposure duration
- Cross-sectional area of beam at a defined point of interest

More information on determining the class of a given laser can be found in the *ANSI Z136.1 Safe Use of Lasers* Standard (a copy is available for review at the Thomson Center for Environmental Management).

<u>Class 1</u>

- Not considered hazardous under normal operating conditions.
- Include devices in which a higher power enclosed laser (3B or 4) operates, substantially limiting or eliminating the emission of harmful laser radiation (laser cutters, for example).
- Exempt from any control measures.

<u>Class 1M</u>

- Generally considered to be safe and incapable of producing hazardous exposure during normal operation unless viewed with collecting optics, such as a microscope or telescope.
- Control measures are to be implemented when:
  - There is the possibility of viewing with collecting optics, or
  - An unattended operation where a beam is directed into a location which may be viewable by the public.

<u>Class 2</u>

- Emit light in the visible region (400 - 700 nm) and are continuous wave.
- Have a power output of less than 1 mW.
- Accidental exposure is generally not considered hazardous as the natural aversion response prevents prolonged exposure.
- Exempt from control measures except for intentional direct viewing.

<u>Class 2M</u>

- Emit light in the visible region (400 - 700 nm) and are continuous wave.
- Have a power output of less than 1 mW.
- Eye protection normally afforded by the aversion response (for unaided viewing).
- Exposure may be hazardous if the laser is viewed with collecting optics. In this case, control measures are required.

Class 3R (formally known as Class IIIa)

- Continuous wave laser with an output up to five times the emission limit for Class 1 or Class 2 lasers (usually 1 – 5 mW) in the visible region.
- Exempt from control measures except for the following conditions:
  - Direct viewing of the beam or specular reflection
  - Unattended operation in which the beam is directed to a location that may be viewed by the public without being informed of the potential hazards.

Class 3B

- Emit light of intensity exceeding the Maximum Permissible Exposure (MPE) for direct viewing and from specular reflection (diffuse reflections are generally not hazardous).
- Continuous wave (CW) emissions shall not exceed 500 mW (0.5 W).
- For pulse laser systems, the output shall not exceed 125 mJ in less than 0.25 seconds.
- Control measures are required unless specified by the LSO.

Class 4

- Emit accessible laser radiation exceeding Class 3B limits (greater than 500 mW or 125 mJ).
- Considered hazardous for direct beam viewing along with beams viewed from specular and diffuse reflections.
- Additional hazards include fire, skin damage, and airborne contaminants.
- Controls beyond those of Class 3B lasers are required.

Embedded Systems

Embedded systems are devices that normally contain a Class 3B or Class 4 laser but are rendered safe and are rated as either Class 1 or Class 2 lasers. Examples include laser cutters, some microscopes, and laser printers. Embedded systems are considered hazardous if their safety mechanisms or interlocks are defeated and the laser can operate without the system's protective cover. In this case, the system will be considered a Class 3B or Class 4 laser.

REFERENCES

ANSI Standards

- *ANSI Z136.1 – 2014, Safe Use of Lasers* outlines MPE limits for users, identifies laser hazard categories, and provides information for determining the appropriate safety measures required for each laser hazard category.
- *ANSI Z136.5 – 2020, Safe Use of Lasers in Educational Institutions*
- *ANSI Z136.8 – 2021, Safe Use of Lasers in Research, Development, or Testing.*

The Food and Drug Administration (FDA)

21 CFR Subchapter J Part 1040 – Performance Standards for Light-Emitting Products regulates both medical and non-medical lasers and generally applies to those who manufacture or modify laser products and describes what is required to ensure a laser product is conforming, including standardized labeling.

International Electrotechnical Commission (IEC)

Standards written by the IEC are used in most countries outside of the United States. IEC 60825 contains similar (but not identical) language to 21 CFR 1040.10. IEC Standards may be applicable when importing lasers from outside of the United States or exporting lasers from the United States. Lasers imported from another country must either meet FDA standards or IEC standards agreed upon by the FDA.