



# **Laser Safety Guidelines**

**Purdue Laser Safety Committee  
Adopted: August 2023**

## **Preface**

*This manual provides laser users with information on laser hazards, policies, safe use recommendations, and training. It is designed to promote safe laser use in research and teaching while avoiding undue costs or use restrictions. The manual draws heavily from the ANSI Z136.1-2022 standard, which is the accepted laser safety standard in the US. Lasers pose significant risks to eyes, skin, and can ignite flammable materials or release hazardous substances. Proper procedures and precautions can mitigate these risks, and the Purdue University Laser Safety Committee has developed this manual to help users operate laser equipment safely. For further assistance, contact a member of the committee or the Laser Safety Officer at the Department of Environmental Health and Safety (EHS) phone 765-494-6371.*

*Lasers are capable of causing eye/skin injury to anyone who looks directly into the laser output beam and under certain conditions a specular/diffuse reflection of the beam may also cause injury. High-power laser beams can also ignite flammable materials, and cause the release of hazardous fumes, gasses, and debris. Other hazards associated with the equipment and optical apparatus required to produce the lasing action and control the beam can include high-voltage, high pressure, compressed gasses, cryogenics, noise, ionizing and non-ionizing radiation, and toxic materials. Further hazard recognition posed by a laser system will be further detailed in the laser classification section.*

*Despite the potential hazards, laser equipment can be operated safely if the proper procedures and necessary precautions are followed. To this end, the Purdue University Laser Safety Committee has developed this manual. If you need additional information or assistance, contact any member of the Committee or the Laser Safety Officer at the Department of Environmental Health and Safety (EHS), phone 765-494-6371*

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## Chapter 1: Introduction

The purpose of this laser safety manual for Purdue University is to ensure that all individuals using lasers in research and teaching environments have access to comprehensive information on laser hazards, safe laser use recommendations, policies and procedures, and laser safety training.

### 1.1 Scope and Applicability

This program applies to all lasers and laser systems operated by Purdue University faculty, staff, students and visiting lab members. This program is based on guidance from ANSI Z136.1-2022, American National Standard for Safe Use of Lasers. All laser users of Purdue University must conduct their work within the requirements of the laser safety program and this manual.

This laser safety manual is not intended to be a fully comprehensive reference for every laser application, but rather as a guide for laser users. Further requirements concerning hazards associated with specific substances, devices, and novel laser applications should be consulted with the Laser Safety Officer (LSO). The proper implementation of this program will assure that laser exposures are always below the maximum permissible exposure (MPE) limits.

### 1.2 Regulatory Requirements and Standards

Purdue University adheres to the guidelines set by the American National Standard Institute, ANSI Z136.1 "Standard for Safe Use of Lasers". This is a voluntary standard that is recognized by the Occupational Safety and Health Administration (OSHA). OSHA requires that all organizations using lasers have a Laser Safety Program but all requirements in the ANSI standard are not required by OSHA. The ANSI Z136.1 series was written for laser users by laser users, and it is the consensus of the laser safety community that it is the best approach to ensure the safe use of lasers.

Lasers purchased from any manufacturer must be compliant with the Federal Laser Product Performance Standard (FLPPS), also called the Center for Devices and Radiological Health (CDRH). The FLPPS requires that laser product manufacturers classify their product and certify that it meets all safety requirements.

The laser safety program is designed to be compliant with the General Duty Clause set by OSHA which states that all employers, including Purdue University, must provide a work environment "free from recognized hazards that are causing or are likely to cause death or serious physical harm."

## Chapter 2: Roles and Responsibilities

### 2.1 Environmental Health and Safety (EHS)

Environmental Health and Safety (EHS) is responsible for providing resources to the LSO and any laser users in an effort to maintain compliance with Purdue's Laser Safety Program. EHS provides laser safety training and consultation services in regards to the appropriate safety equipment, lab setup, and safety procedures.

### 2.2 Laser Safety Committee Charter (LSC)

Purdue University's Environmental Health and Safety Compliance Policy (IV.A.4) definitions section states the Laser Safety Committee was "formed in order to promote the safe use of lasers and laser systems at the University's campuses, research farms and related facilities and operations, and at temporary job sites in accordance with the American National Standard for Safe Use of Lasers (ANSI Z136.1)." The Laser Safety Committee meets on a semiannual basis to discuss operations of the Laser Safety Program, approve projects utilizing class 3B and 4 lasers/laser systems, and to address safety matters and practices regarding the use of lasers on campus. All new laser projects or amendments to current projects must be approved by the laser safety committee. Contact LSO for all required documentation for committee approval.

The specific duties and responsibilities of the Laser Safety Committee shall include, but are not limited to, the following:

- Serve as advisors to the University Community on matters related to lasers and laser systems.
- Be cognizant of all applicable federal, state, or recognized consensus standards and University policies, procedures, guidelines, laws and regulations related to lasers and laser systems and transmit this information in appropriate form to the University Community.
- Develop, review, and/or approve procedures and guidelines, and prescribe special conditions and requirements related to Class 3B and 4 lasers.
- Develop, review, approve, and recommend programs for training in laser safety in the University Community.
- Review conditions not in compliance with government and/or University policies, procedures, guidelines and regulations, and recommend appropriate corrective actions. In extreme circumstances, this may include suspension of the activity in question.
- Report items addressing safety or response related to an injury to the department head of the PI.
- Keep a written record of activities, actions, decisions and recommendations of the Committee.

## 2.3 Laser Safety Officer (LSO)

The Laser Safety Officer is appointed by the Laser Safety Committee as the individual responsible for managing the Laser Safety Program. The LSO and EHS will conduct annual laser safety assessments of all class 3B and class 4 laser laboratories and any laser laboratory deemed necessary. Class 3B and class 4 lasers shall be operated only with the written approval of the LSO. Additionally, the LSO shall have the final authority in determining if laser control measures are adequate or if alternate controls are necessary. The LSO shall have the authority to terminate laser operations at any time.

The LSO is responsible for the following but not limited to:

- Assure the proper classification of all lasers.
- Performing hazard evaluations for all class 3B and 4 lasers and laser work areas.
- Monitoring the laser program and assuring compliance from laser users.
- Ensuring that laser users have proper protective equipment (PPE).

## 2.4 Principle Investigator (PI)

The Principal Investigator (PI) is directly responsible for ensuring adherence to the laser safety program. PIs are responsible for the following but not limited:

- Registering every class 3B and class 4 laser system by submitting a laser registration form LS-1 to EHS.
- Maintain an updated roster of laser users under their laser use authorization (LUA) and that they have completed their training requirements as outlined in the training requirements section of this manual.
- Inform the LSO of any new laser projects or amendments to existing laser projects.
- Notify the LSO and laser users of any new suspected hazards or changes to how a laser system is being operated.
- Ensure that lasers are operated as intended within established safety procedures.
- Maintain all current SOPs for their lab.
- Maintain an LSO approved beam alignment SOP for all class 4 and 3B laser alignments.

## 2.5 Laser Users

All individuals seeking to use a class 3B or a class 4 laser system under a PI's authorization must become an authorized laser user. All laser users must meet the training requirements outlined in the training section of this manual. Additionally, all laser users have the minimum responsibilities:

- Read, understand, and adhere to specific lab standard operating procedures (SOPs).
- Receiving the appropriate hands-on training from their PI or another lab member designated by the PI.

- Reporting any safety concerns to the PI and LSO.
- Following any additional campus or lab specific safety procedures, requirements or policies.
- Ensure all individuals present in the lab wear appropriate personal protective equipment (PPE) and additionally appropriate lab attire in accordance with campus laboratory hazard requirements.
- All injuries and accidents involving lasers shall be immediately reported to the PI and the LSO. See the Emergency Response section (Chapter 8).

## Chapter 3: Laser Classification

The hazard class of any laser is vital to determining what appropriate safety precautions are necessary to ensure laser operation is safe. The laser hazard class is designated according to their accessible radiation during normal operation, it should be noted that if a laser is modified it may require reclassification. The laser classification will be based on the maximum output power or radiant energy available. For laser systems capable of emitting energy at numerous wavelengths, the classification shall be based on the most hazardous wavelength region.

Lasers modified at Purdue University must be evaluated by the LSO or an appointee by the LSO to be appropriately classed. It is also the responsibility of the Laser Principal Investigator (LPI) to assist the LSO by supplying correct laser technical specifications to the LSO.

### 3.1 Class 1 Laser

1. Class 1 laser systems are considered incapable of producing damaging laser radiation during normal operation and are exempt from any control measures.
2. Higher class lasers that are fully enclosed can be redesignated as a class 1 laser; this is typically the case for high powered laser cutting systems where the beam cannot be accessed during normal operating conditions.
3. Examples: Laser printers and enclosed laser cutting systems. Only the LSO or manufacturer may reclassify a laser system to be class 1.

### 3.2 Class 1M Laser

1. Class 1M Lasers are safe with direct eye contact, but may become hazardous with the aid of optical instruments.
2. Class 1M Lasers have large or divergent beams.
3. Examples: Alignment Lasers

### 3.3 Class 2 Laser

1. The natural aversion response, where a person turns away or blinks to avoid bright light is considered adequate protection against class II laser exposure.
2. Staring into the beam of a class 2 laser system is hazardous.
3. Class 2 Lasers operate in the visible region of light (380-700 nm) and have power less than 1 mW.
4. Examples: Barcode Scanners

### 3.4 Class 3B Laser

1. Output 5 - 500 mW in the visible region and invisible region, they may be pulsed or continuous wave.



2. The natural aversion response does NOT provide adequate protection to direct beam exposure to the eyes.
3. Class 3B lasers can produce a hazard if viewed directly, including intrabeam viewing of specular reflections.
4. Normally, Class 3B lasers are not a fire hazard, diffuse reflection hazard, nor a laser generated air contaminant (LGAC) production hazard.
5. Examples: Raman laser microscopes

### **3.5 Class 3R Laser (Formerly 3A)**

1. Continuous wave emission between 1 - 4.99 mW in the visible and invisible region.
2. Class 3R is potentially hazardous under some direct and specular reflection viewing conditions if the exposure time is large.
3. Class 3R lasers do not pose a fire hazard or diffuse reflection hazard.
4. Examples: laser pointers.

### **3.6 Class 4 Laser**

1. The highest laser hazard class output power for continuous wave systems is greater than 500 mW and for pulsed lasers that are capable of producing over 125mJ in less than 0.25 seconds.
2. Aversion response does NOT provide adequate protection to direct beam exposure. Diffuse reflections can be a hazard to the eyes and skin.
3. Sufficient power to ignite materials.
4. May produce laser generated airborne contaminants that are hazardous to breathe.
5. Laser safety eyewear and barriers are required for safe operation.
6. Examples: Ti-Sapphire Laser, Nd:YAG.

## Chapter 4: Laser Reclassification

In general, the use of magnifying glasses increases the hazard from a widely-diverging beam (e.g., LEDs and bare laser diodes), and binoculars or telescopes increase the hazard from a wide, collimated beam. These optical aiding devices can increase the nominal hazard zone of a lower-class laser system and may be reclassified to a greater laser class by the LSO. The LSO may reclassify a class 4 laser to a class I if the beam is fully enclosed as per specifications under the ANSI Z136 Standard.

## Chapter 5: Beam Hazards

Laser classes 3B and 4 are considered dangerous for eye and skin hazards. The direct beam, diffuse reflections, or specular reflections from a laser can damage tissue due to the intense light amplification and high energy deposition density of lasers. These effects on the eyes and skin are both photochemical and thermal depending on the wavelength of laser light. Symptoms range from mild reddening (erythema) to blistering and charring of tissue.

### 5.1 Eye Injury

Eyes are the most sensitive organ for laser light. The location and type of injury will depend on the type laser, the wavelength (see Table 1), the power, and the uses of the laser system. Laser safety precautions are therefore crucial to protect against such injuries. Intrabeam viewing, which refers to the direct viewing of a laser beam with the naked eye, is particularly dangerous as it can cause severe damage to the retina. Specular reflection occurs when a laser beam is reflected off a smooth surface and can cause injury to the eye if it is viewed directly. Diffuse reflections, on the other hand, occur when a laser beam is reflected off a rough or irregular surface and can cause scattered light to enter the eye, potentially leading to injury. Proper laser safety measures, such as using protective eyewear and ensuring proper laser setup and use, can help prevent these types of injuries.

Wavelength (nm)	Type of Injury
180-400	Thermal, photochemical injury to cornea (e.g., photo keratitis or welder's flash), and photochemical injury to lens (e.g., cataracts).
400-600	Thermal, and photochemical injury to retina (Greater blue light retinal hazard at shorter wavelengths)
400-1400	Micro cavitation to retina
600-1400	Thermal injury to retina
1400-2600	Thermal injury to cornea or lens
> 2600	Thermal injury to cornea (Mostly surface burns)

**Table 1.** Eye Injuries at Various Wavelengths

### 5.2 Skin Injury

Skin injuries consist of erythema (sunburn), skin cancer, accelerated skin aging, hyper pigmentation, skin darkening, and burns. The severity of skin injuries depends on the laser wavelength, power, and duration of exposure.

## Chapter 6: Non-beam Hazards

While laser beams are the most obvious hazard associated with lasers, they are not the only danger. Non-beam hazards include but are not limited to; fumes, compressed gasses, cryogenic materials, noise in excess of 70 dB, electrical hazards, flammable materials, and explosives.

### 6.1 Electrical Hazards

Shocks are the most common injuries to personnel involving lasers. Most laser systems contain power supplies with high voltages that are extremely hazardous. Electrical hazards can arise from discharging capacitor banks or improper grounding of laser equipment. Only qualified and authorized personnel should ever work with energized laser power supplies.

Electrical Hazards to be aware of include:

1. Frayed or torn cords
2. Liquid Cooling tubes near electrical sources
3. Cut grounding plugs
4. Daisy chaining power cords
5. Exposed circuit boards or power supplies

### 6.2 Laser Generated Airborne Contaminants (LGACs)

Laser cutters/welders or other materials processing systems will often vaporize material creating particles that are a respiratory hazard. Additionally, lasers can produce fumes or vapors that can be harmful to health if inhaled. Any LGACs must be removed from the work environment via exhaust systems.

### 6.3 Fire Hazards

1. Fire hazards can arise from the use of combustible materials near laser equipment, such as paper or fabric. Oftentimes laser related fires are caused by the use of a non-laser rated beam barrier. Typical home curtains or drapes are NOT appropriate for enclosing a laser. Ensure that fire extinguishers are placed within reach in case of an emergency.

### 6.4 Mechanical Hazards

This section details the minimum PPE requirements for all laboratories using hazardous Compressed gasses are used in some laser applications. These compressed gasses are capable of rapid release that will propel the gas cylinder if not properly secured. Additionally, some require gas cabinets. For more information about compressed gasses please see the Compressed Gas Safety Training.

Laser systems often have moving parts, such as mirrors, lenses, and rotating components. If these parts are not properly secured or maintained, they can lead to entanglement, crushing, or shearing hazards

## **6.5 Chemical Hazards**

Certain lasers require the use of hazardous chemicals, such as toxic or reactive gas, as part of their operation. Accidental leaks or releases of these chemicals can pose health risks to personnel and may require proper ventilation and handling procedures. Chemical hazards associated with lasers, particularly those involving dyes, can arise from the materials used in the laser's active medium or dye solution. Dye lasers are a type of laser that use organic dye molecules dissolved in a liquid solvent as the gain medium. While dye lasers can offer tunable wavelengths and high-energy pulses, they also present certain chemical risks. Many dye molecules used in dye lasers are organic compounds that can be toxic or harmful if ingested, inhaled, or absorbed through the skin. Exposure to these chemicals can lead to health issues ranging from irritation to systemic toxicity. For a complete list of chemical hazards please see the Chemical Hygiene Plan.

## Chapter 7: Laser Class Control Measures (Class 3B and 4)

Laser class control measures are design features and safety procedures required for different classes of lasers to prevent accidental exposure to laser radiation and protect individuals from harm. There are three principal types of laser class control measures, namely engineering controls, administrative/procedural controls, and personal protective equipment. For the purposes of this manual, class 3B and class 4 laser control measures are discussed. In general, it is preferable to enclose the beam path where possible. Personal protective equipment is of vital importance but should be considered as a last line of defense against laser injury. The LSO will determine the laser class control measures for each class 3B and 4 system in accordance with the ANSI Z136.1 standard.

### 7.1 Laser Control Area (LCA)

For any lab space that contains a class 3B or class 4 laser, the LSO will conduct a laser hazard assessment, which involves establishing the Maximum Permissible Exposure (MPE) and the Nominal Hazard Zone (NHZ). If the evaluation indicates that the highest accessible radiation level falls under Class 3b or 4, a Laser Control Area is indicated, accompanied by the implementation of LCA measures. These measures are mandatory within the confines of the LCA.

#### 7.1.1 Class 3B LCA

1. Area must be kept only accessible to authorized personnel.
2. Must have appropriate laser control area warning sign(s). See appendix B.
3. Beam path must never escape the LCA under any circumstances.
4. The beam path should be well defined and obvious to lab personnel.
5. Beams must be safety terminated.
6. Beam path should not be level with the eyes or from any seated position. Keep computer chairs and workstations away from line of sight of any optical tables.
7. All windows, doorways, entry ways, etc. must be covered or restricted in such a manner that it is impossible to be exposed to the laser inside the lab.
8. Appropriate eyewear must be accessible before entering the LCA.
9. All authorized users must be up to date on their required safety training.
10. Optical tables and any surfaces near the beam must be non-reflective and free of reflective optics that are not being actively used.

#### 7.1.2 Class 4 LCA

A class 4 laser-controlled area requires the class 3b area control measures in addition to:

1. The class 4 laser must be interlocked to the LCA entryway to prevent unauthorized users from entering rooms and exceeding the MPE. Additionally, it is sufficient to have laser rated barriers in front of entryways. Eyewear should be placed on a

protective barrier or nearby to allow users to grab their eyewear before proceeding behind the barrier to the laser.

2. On the outside of the entryway there must be a laser warning device that indicates when the laser is energized and emitting.

## 7.2 Engineering Controls

Listed below are the engineering controls required for Class 3b and 4 lasers at Purdue University, unless otherwise approved by the Laser Safety Officer (LSO). The design features include a protective interlocked housing, interlocked service access panels, a key controlled master switch for Class 3b and 4 lasers, appropriate viewing portals and collecting optics, a designated laser-controlled area, a remote interlock connector, a permanent beam stop, and an alarm or warning system during start-up and operation. See Table 2 for a summary of engineering controls. Those engineering controls with a **“Shall”** requirement are **not optional**.

Engineering Control Measures	Laser Classification	
	3B	4
Laser Controlled Area	+	+
Laser Warning Sign	+	+
Protective Housing	+	+
Protective Housing Interlocks	+	+
Area Warning Device	•	+
Laser Radiation Emission Warning Device	•	+
Entryway controls	+	+
Protective Barriers and Curtains	•	•
Beam Dumps	-	•

**Table 2.** Engineering Controls for Class 3B and 4 Lasers\*

**\* Table 2 Legend:**

- + = Shall
- = Should
- = No Requirement

### 7.3 Administrative and Procedural Controls

Administrative/procedural controls are measures (see Table 3) that are put in place to ensure the safe use of Class 3B or 4 lasers. These controls involve implementing policies, procedures, and training programs that are designed to minimize the risks associated with working with high-powered lasers.

1. Maintain a standard operating procedure (SOP) for the laser lab of what lasers are present and how they are operated safely.
2. Additionally keep a separate alignment SOP.
3. Enforce the lab as authorized personnel space and bar entry to unauthorized individuals.
4. Maintain beam height at a level that is never eye level from seated or standing positions. Often this involves removing chairs from a laser lab to prevent seated positions.

Administrative Control Measures	Laser Classification	
	3B	4
Standard Operating Procedures	•	+
Education and Training	+	+
Authorized Personnel	+	+
Alignment Procedures	+	+

**Table 3.** Administrative Control Measures for Class 3B and 4 Lasers\*\*

**\*\* Table 3 Legend:**

- + = Shall
- = Should
- = No Requirement



## 7.4 Personal Protective Equipment

Personal protective equipment (PPE) is an essential component of laser safety programs. PPE is designed to protect workers from potential hazards associated with laser use, including eye and skin damage. Laser safety glasses, goggles or face shields are typically required to protect the eyes from laser radiation. In addition, protective clothing made from materials that reflect or absorb laser radiation, such as heavy cotton, leather or Kevlar, may be necessary to protect the skin from burns or other injuries. The type of PPE required will depend on the power and wavelength of the laser, as well as the intended use and operating environment. It is important to ensure that PPE is appropriate for the laser being used, properly fitted, and in good condition to effectively protect the user from laser hazards. Proper training on the use and care of PPE is also necessary to ensure that workers use it correctly and consistently. In addition to the appropriate PPE, workers using Class 3B or 4 lasers may need to use eyewear with a specific optical density (OD) to protect their eyes from laser radiation. The OD of eyewear is determined by the wavelength and power of the laser being used and is designed to reduce the intensity of the laser beam to safe levels. Eyewear with an incorrect OD may not provide adequate protection, leading to serious eye injuries. Therefore, it is critical to ensure that eyewear used for laser work has the appropriate OD for the specific laser being used.

## 7.5 Laser Alignment

Most beam injuries occur during alignment. Only trained personnel may align class 3B or class 4 lasers. Beam alignment is the process of directing a laser beam so that it travels in a desired path. This can be a dangerous task, as the beam path is moving. Accidents most often happen during laser beam alignment. It is important to always wear laser safety glasses during beam alignment. Because laser labs can be set up in a variety of different ways, every laser needs its own standard operating procedure for beam alignment. This SOP must be approved by the LSO.

Common procedural controls for beam alignment.

1. If possible lower the beam to its lowest power.
2. When possible, use a lower powered visible laser for path simulation vs higher powered invisible or visible lasers.
3. When aligning an invisible beam use IR cards or image converter tools to trace the invisible beam path.
4. Always wear the appropriate laser safety glasses.
5. Keep the laser beam inside the designated laser-controlled area LCA.
6. Exclude unnecessary personnel from the LCA during beam alignment
7. Keep the work environment free of reflective surfaces. Unused optics should be placed inside storage.

## Chapter 8: Emergency Response

In the event of a severe injury, please follow these guidelines:

1. Contact the University Police for ambulance assistance at 911.
2. Provide necessary life-saving measures.
3. Refrain from moving a seriously injured individual unless they are at risk of further harm.
4. Notify Environmental Health and Safety at (765) 494-6371.

### 8.1 Non-Immediate Emergencies

Employees and students are required to inform their immediate supervisor or instructor, as well as Environmental Health and Safety (EHS), of any injuries resulting from exposure to lasers. If medical attention is needed, individuals at the West Lafayette campus should go to the Regional Occupational Care Center (ROCC) on Creasy Lane in Lafayette. Additionally, a First Report of Injury must be submitted.

Laboratories must outline the prescribed steps to be taken in the event of an accident, injury, fire, or any other emergency situation. This includes providing the relevant contact information of individuals who must be notified in case of an emergency. Emergency procedures should prominently display the REM contact at 768-494-6371 and Purdue Police at 911 or 765-494-8221. Additionally, ensure that the emergency protocols are posted visibly within the laboratory premises.

Detail your planned course of action in the occurrence of an accident, injury, fire, or any emergency scenario. Remember to include the names and contact numbers of the designated personnel to be contacted during such situations. In case of an emergency, immediately reach out to REM at 765-494-6371 and Purdue Police at 911 or 765-494-8221 as indicated. It is crucial to prominently display the emergency procedures within the laboratory, ensuring their visibility and accessibility to all individuals present.

## **Chapter 9: Program Requirements**

### **9.1 Laser User Application (LUA)**

Every LPI of Purdue University that uses a class 3B or 4 lasers must complete all forms for the laser use authorization process (see Appendix A). The LUA consists of 2 forms, LU-1 form: Laser User Application, LS-1 form: Laser Registration. LPI's must submit all LUA forms and receive approval from the LSO prior to the use of any class 3B or 4 lasers. In addition to the registration forms, all Principal Investigators are required to have all necessary Standard Operating Procedures available prior to project approval. All new LUA applications will be presented in the next LSC meeting. LUA's are reviewed annually by the LSO and can be temporarily suspended or terminated by order of the LSO or LSC if they feel that the safety of the laser system is compromised or poses an immediate danger to the public. The LSO or their designee maintains documentation of all changes to a LUA.

### **9.2 Acquisition, Modification, Sale or Transfer of Lasers**

All acquisition, modification, sale, or transfer of lasers should be communicated to the LSO. When acquiring lasers, it is essential to thoroughly evaluate the intended purpose, laser class, and power requirements to ensure suitability for the intended application. Additionally, proper documentation and record-keeping should be maintained to track the acquisition process. PI's must submit a laser registration LS-1 form to EHS.

Any modification of lasers should only be carried out by qualified personnel following approved procedures. Alterations to lasers, such as changes in power levels or beam divergence, should be carefully evaluated for their impact on safety and performance. It is crucial to consult with laser safety experts or manufacturers to ensure that modifications comply with regulatory requirements and do not compromise the integrity or safety of the laser system.

### **9.3 Decommissioning and Disposal of Lasers**

Labs wishing to decommission or dispose of their lasers should contact the LSO for determining proper disposal methods. Labs wishing to transfer their laser to another lab must notify the LSO of the transfer.

### **9.4 Laser Safety Training, Laser Safety Refresher Training**

Operators of class I, class 1M, 2, and 3R lasers and laser systems as well as all incidental personnel or laser-controlled area visitors shall receive a laser safety briefing from the LSO or a responsible Laser Principal Investigator of that laser system before operating the laser or entering the laser-controlled area.

All operators and ancillary personnel of class 3B and 4 lasers shall receive an initial laser safety training online before operating the laser, this includes the LPI. Class 3B and class 4 lasers

must also take a refresher training every two years from the date of their initial laser safety training. Laser users may complete the "Laser Classes 3B and 4 -Initial" Training at the EHS training webpage. At the end of the training, the user must complete and pass the Laser Safety Training Quiz.

The "Laser Classes 3B and 4 - Initial" training expires after two years from the completion date. All users intending to continue working with class 3B and 4 lasers after the initial training expiration date, must complete a refresher training. The refresher training can also be found at the REM's list of training webpage.

## 9.5 Laboratory Signs and Equipment Postage

The following requirements apply to laboratory signs regarding Class 3B and Class 4 lasers,

Laser Area Signage:

1. Signs must be posted at the entrances to areas where Class 3B or Class 4 lasers are in use.
2. The sign should include the laser's class designation (e.g., Class 3B or Class 4) and any additional hazard information required.
3. The sign must be easily visible and legible from all entry points to the laser area.

Interlocked Area Signage:

1. Signs must be posted at entrances to interlocked laser areas.
2. The sign should include the laser's class designation and any additional hazard information.
3. The sign should indicate the need for authorization or control access before entering the area.

"Laser in Use" Signage:

1. A "laser in use" sign is required whenever a laser is energized and emitting laser radiation.
2. The sign should be placed at the entrance to the LCA.
3. Bike lights or other lights are not appropriate.

## 9.6 Record Keeping Requirements

Laser labs must notify EHS of the acquisition or transfer of any lasers. This notification should be made as soon as possible after the acquisition or transfer. EHS will use this information to track the lasers in the lab and to ensure that they are being used safely.

Laser labs must keep a list of laser users and laser inventory. The list of laser users should include the name, contact information, and training status of all personnel who are authorized to use lasers in the lab. The laser inventory should include the type, model, and serial number of all lasers in the lab. The inventory should be maintained as necessary to ensure that it is accurate and up to date.

## **Chapter 10: Audits and Inspections**

EHS will conduct periodic audits every calendar year for all class 3B and IV laser systems.

These audits will inspect the engineering controls, administrative and procedural controls, and personnel protective equipment. The LSO must be notified of any significant changes to the laser system including but not limited to changes in operating wavelength, power, beam path, LGAC generation, etc.

## Glossary

1. **Accessible Emission Limit (AEL)** - The maximum allowable emission level of a laser device.
2. **AEL** - Accessible Emission Limit
3. **ANSI** - American National Standards Institute
4. **Beam Alignment** - The process of aligning laser beams to achieve proper functionality while minimizing hazards.
5. **Beam Divergence** - The expansion of a laser beam's diameter as it propagates over a distance.
6. **Beam Hazard** - The potential danger posed by direct exposure to laser beams.
7. **CDRH** - Center for Devices and Radiological Health
8. **Class 1 Laser** - A laser that does not emit hazardous levels of laser radiation.
9. **Class 2 Laser** - A low-power visible laser that poses a low risk of eye injury.
10. **Class 3B Laser** - A moderate-power laser that poses a significant risk of eye and skin injuries.
11. **Class 3R Laser** - A medium-power laser that can potentially cause eye injuries if viewed directly.
12. **Class 4 Laser** - A high-power laser that poses a severe risk of eye and skin injuries and fire hazards.
13. **Diffuse Reflection** - Reflection of laser radiation in various directions, reducing the risk of direct exposure.
14. **EHS** - Environmental Health and Safety
15. **FLPPS** - Federal Laser Product Performance Standard
16. **Key Control** - Preventive measures to control access to lasers and laser-controlled areas.
17. **Laser Biohazards** - Potential health risks associated with laser use on biological tissues.
18. **Laser Controlled Area** - A defined area where access is restricted due to potential laser hazards.
19. **Laser Eyewear** - Specialized goggles or glasses designed to protect the eyes from laser radiation.
20. **Laser Hazard Analysis** - Evaluation of potential laser hazards, risks, and safety measures.
21. **Laser Hazard Control Measures** - Protective measures implemented to minimize laser hazards.
22. **Laser Incident** - An event involving a laser-related injury, damage, or safety violation.
23. **Laser Induced Damage** - Harm or impairment caused by exposure to laser radiation.
24. **Laser Interlock System** - A safety mechanism that disables the laser when certain conditions are not met.
25. **Laser Plume** - Smoke or vapor generated when lasers are used on biological tissue.
26. **Laser Principal Investigator (LPI)** – Principal Investigator that the laser belongs to.
27. **Laser Safety Audit** - An evaluation of laser safety practices, procedures, and controls in a facility.

28. **Laser Safety Audit** - An evaluation of laser safety practices, procedures, and controls in a facility.
29. **Laser Safety Cabinet** - A specially designed enclosure for safely operating lasers and containing hazardous materials.
30. **Laser Safety Checklist** - A list of items or actions to be reviewed or completed to ensure laser safety compliance.
31. **Laser Safety Eyewear** - Protective eyewear designed to filter or block specific wavelengths of laser radiation.
32. **Laser Safety Manual** - A document outlining laser safety policies, guidelines, and procedures specific to an organization or facility.
33. **Laser Safety Officer (LSO)** - An individual responsible for overseeing laser safety programs and procedures.
34. **Laser Safety Program** - A comprehensive set of policies and procedures to ensure safe laser use.
35. **Laser Safety Training** - Instruction and education on safe laser handling and practices.
36. **Laser Warning Labels** - Labels affixed to lasers and laser-controlled areas to provide visual warnings and information.
37. **LCA** – Laser Control Area
38. **LGAC** - Laser Generated Airborne Contaminant
39. **LPI** - Laser Principal Investigator
40. **LSO** – Laser Safety Officer
41. **MPE** - Maximum Permissible Exposure
42. **LUA** – Laser Use Authorization
43. **NHS** – Nominal Hazard Zone
44. **NOHA** - Nominal Ocular Hazard Area
45. **NOHD** - Nominal Ocular Hazard Distance
46. **Nominal Hazard Zone (NHZ)** - The area in which laser radiation levels exceed the applicable MPE limits.
47. **Nominal Hazard Zone (NHZ) Calculation** - Determining the boundaries of the NHZ based on laser parameters.
48. **Nominal Ocular Hazard Area (NOHA)** - The area within the NOHD where direct eye exposure to the laser beam is hazardous.
49. **Nominal Ocular Hazard Distance (NOHD)** - The distance from the laser where the laser beam is considered safe for eyes.
50. **OSHA** - Occupational Safety and Health Administration
51. **PPE** - Personal Protective Equipment
52. **Principal Investigator (PI)** – Holder of an independent grant and lead researcher for the grant project. It is also synonymous with “head of laboratory” or “research group leader”. The person who makes the final decisions and supervises funding and expenditures on a given research project.
53. **SOP** - Standard Operating Procedure



# Appendix A:

## Laser Use Forms

See the *EHS Forms* webpage for usable copies of the following laser safety forms.

- Form LF-1 – Laser Facility Approval Request
- Form LS-1 – Laser Registration
- Form LU-1 – Laser Project Application

## A.1 Form LF-1 – Laser Facility Approval Request

Laser Form LF-1

**PURDUE UNIVERSITY**  
**Laser Safety**

### Laser Facility Approval Request

**Laser Facility Information**

Type of Request	Facility Usage
<input type="checkbox"/> New Facility <input type="checkbox"/> Amendment <input type="checkbox"/> Transfer	<input type="checkbox"/> Research & Development <input type="checkbox"/> Teaching & Demonstration <input type="checkbox"/> Research & Application <input type="checkbox"/> Storage Only

Building: \_\_\_\_\_ Room: \_\_\_\_\_

Laser Principal Investigator (LPI): \_\_\_\_\_

Last Name
First Name
Middle Initial

1. Are all personnel working in the Laser Control Area approved laser users?  Yes  No
2. Are laser area warning sign(s) present at the nominal hazard zone?  Yes  No
3. Are standard operating procedures (SOPs) available?  Yes  No
4. Is the laboratory also used as a study/office area?  Yes  No
5. Do you share the laboratory with other LPis\*?  Yes  No

**Laser Principal Investigator Affirmation**

*I affirm that the statements contained in this application are correct and complete to the best of my knowledge.*

Principal Investigator (PI) Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Approvals**

Approval Recommended (LSC): \_\_\_\_\_ Date: \_\_\_\_\_

Approval Granted (LSC Chair): \_\_\_\_\_ Date: \_\_\_\_\_

**Comments**

**Complete the Facility Sketch on Page 2 of 2**

\* Only one LPI can have jurisdiction over a unique laser.

Revised: December 19, 2023

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**Facility Sketch**

Building: \_\_\_\_\_ Room: \_\_\_\_\_

*Sketch the facility and outline in red those areas where lasers will be used and/or stored. The laser safety officer will define the Laser Hazard Control Area.*



## A.2 Form LS-1 – Laser Registration

Laser Form LS-1

**PURDUE UNIVERSITY**  
**Laser Safety**  
**Laser Registration**

**Laser Type, Location, and Registrant**

Stationary Indoor    
  Mobile Indoor    
  Stationary Outdoor    
  Mobile Outdoor

Primary Location (Building): \_\_\_\_\_ Room: \_\_\_\_\_

Laser Principal Investigator (LPI): \_\_\_\_\_  

Last Name
First Name
Mobile Initial

Department: \_\_\_\_\_ Email: \_\_\_\_\_  
Purdue Email Address Preferred

**Laser System Specifications**

Manufacturer: \_\_\_\_\_ Model: \_\_\_\_\_

Laser Type: \_\_\_\_\_ Class: \_\_\_\_\_ System Date: \_\_\_\_\_

Serial #: \_\_\_\_\_ Purdue University Inventory #: \_\_\_\_\_

Required [SOPs](#) are posted:  Yes  No

Beam diameter & divergence measured at:  1/e point  1/e<sup>2</sup> point

Beam Shape is:  Circular  Elliptical  Rectangular  Multiple Array: \_\_\_\_\_

Beam Diameter<sub>1</sub> (mm): \_\_\_\_\_ Beam Divergence<sub>1</sub> (mradian): \_\_\_\_\_

Beam Diameter<sub>2</sub> (mm): \_\_\_\_\_ Beam Divergence<sub>2</sub> (mradian): \_\_\_\_\_

Beam Interlocks are:  Fail-Safe  
 Fallible (Explain how interlock(s) is/are fallible )  
 \_\_\_\_\_

All service to the laser will be performed by a certified technician from the manufacturer or equivalent (i.e., has training documentation for laser service and electrical safety).  Yes  No

<input type="checkbox"/> <b>Continuous Wave (CW)</b>	<b>Pulsed:</b> ( <input type="checkbox"/> Single <input type="checkbox"/> Multiple)
Wavelength (nm): _____ Maximum Operating Power (W): _____ Average Operating Power (W): _____	Wavelength (nm): _____ Maximum Operating Energy (J): _____ Average Operating Energy (J): _____ Minimum Pulse Duration (sec.): _____ Maximum Pulse Frequency (Hz): _____

**Check Appropriate Box for Items Below**

Yes No	Yes No
<input type="checkbox"/> <input type="checkbox"/> High voltage used (> 600 volts)	<input type="checkbox"/> <input type="checkbox"/> Dye laser
<input type="checkbox"/> <input type="checkbox"/> High voltage supplies are accessible (> 30 kVp)	<input type="checkbox"/> <input type="checkbox"/> Use of cryogenics
<input type="checkbox"/> <input type="checkbox"/> Energized parts are placed in safe working condition	<input type="checkbox"/> <input type="checkbox"/> Use of compressed gases
<input type="checkbox"/> <input type="checkbox"/> Use of beam focusing optics	<input type="checkbox"/> <input type="checkbox"/> Ionizing radiation hazard
<input type="checkbox"/> <input type="checkbox"/> Tunable laser	<input type="checkbox"/> <input type="checkbox"/> Magnet hazard
<input type="checkbox"/> <input type="checkbox"/> Used as a pumping laser	<input type="checkbox"/> <input type="checkbox"/> Plasma hazard
<input type="checkbox"/> <input type="checkbox"/> Exposed beam path	<input type="checkbox"/> <input type="checkbox"/> Robotics used
<input type="checkbox"/> <input type="checkbox"/> Laser Generated Air Contaminants (LGACs) produced	<input type="checkbox"/> <input type="checkbox"/> High Noise hazard
<input type="checkbox"/> <input type="checkbox"/> Home-fabricated or self-modified laser	<input type="checkbox"/> <input type="checkbox"/> Used for machining

Revised: December 19, 2023

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### A.3 Form LU-1 – Laser Project Application

Laser Form LU-1					
<p><b>PURDUE UNIVERSITY</b>  <b>Laser Safety</b></p> <p><b>Laser Project Application</b></p>					
<p><b>Laser Project Information</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;"><b>Type of Application</b></td> <td><b>IMPORTANT:</b> All Class 3B and Class 4 laser use at Purdue University is subject to approval by the Purdue University Laser Safety Committee (LSC) as designated in the policy on Environmental Health and Safety Compliance (IV.A.4). All laser projects must comply with the ANSI Z136.1 laser safety standard to obtain and maintain LSC approval. Environmental Health and Safety (EHS) administers the laser safety program at Purdue University and makes recommendations to the LSC regarding approvals.</td> </tr> <tr> <td> <input type="checkbox"/> New Project  <input type="checkbox"/> Amendment  <input type="checkbox"/> Transfer         </td> <td></td> </tr> </table>		<b>Type of Application</b>	<b>IMPORTANT:</b> All Class 3B and Class 4 laser use at Purdue University is subject to approval by the Purdue University Laser Safety Committee (LSC) as designated in the policy on Environmental Health and Safety Compliance (IV.A.4). All laser projects must comply with the ANSI Z136.1 laser safety standard to obtain and maintain LSC approval. Environmental Health and Safety (EHS) administers the laser safety program at Purdue University and makes recommendations to the LSC regarding approvals.	<input type="checkbox"/> New Project <input type="checkbox"/> Amendment <input type="checkbox"/> Transfer	
<b>Type of Application</b>	<b>IMPORTANT:</b> All Class 3B and Class 4 laser use at Purdue University is subject to approval by the Purdue University Laser Safety Committee (LSC) as designated in the policy on Environmental Health and Safety Compliance (IV.A.4). All laser projects must comply with the ANSI Z136.1 laser safety standard to obtain and maintain LSC approval. Environmental Health and Safety (EHS) administers the laser safety program at Purdue University and makes recommendations to the LSC regarding approvals.				
<input type="checkbox"/> New Project <input type="checkbox"/> Amendment <input type="checkbox"/> Transfer					
Laser Principal Investigator (LPI): _____					
Department: _____	<small>Last Name</small> <small>First Name</small> <small>Middle Initial</small>				
Telephone: _____	Position: _____				
Email: _____	Office: _____				
<small>Purdue Email Address Preferred</small> <small>Building &amp; Room</small>					
<ol style="list-style-type: none"> <li>1. Laser Systems (attach Registration form <a href="#">LS-1</a> for each Class 3B and Class 4 laser)</li> <li>2. Laser Facilities (attach Facility Approval Request form <a href="#">LF-1</a> for each facility housing a Class 3B or Class 4 laser)</li> <li>3. Describe how the laser will be used for the project.</li> </ol> <div style="border: 1px solid black; height: 80px; margin-top: 5px;"></div>					
<ol style="list-style-type: none"> <li>4. Attach <a href="#">standard operating procedures (SOPs)</a> for each laser system (Mandatory SOPs include information about normal operation, routine maintenance, service, alignment, personal protective equipment, emergencies, and any applicable non-beam hazards. The laser manufacturer's manual is not an acceptable substitution.)</li> <li>5. Is there any chance that gas or aerosols will be formed?    <input type="checkbox"/> Yes    <input type="checkbox"/> No          If so, what method(s) will be used to prevent inhalation of the released gas or aerosols?</li> </ol> <div style="border: 1px solid black; height: 40px; margin-top: 5px;"></div>					
<ol style="list-style-type: none"> <li>6. Indicate what methods will be used to define a Laser Control Area. This area is designated where the laser has the potential to cause injury (the entire room, inside laser curtain, behind protective barrier, etc.)</li> </ol> <div style="border: 1px solid black; height: 40px; margin-top: 5px;"></div>					
<p><b>Continued on Page 2</b></p>					
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7. Specify precautions and procedures personnel will use to:

a.) Prevent eye and/or skin injuries

b.) Prevent unauthorized use or removal of the laser system

c.) Prevent beam exposure in work areas and in adjacent area

d.) Prevent beam exposure to public (i.e., non-project personnel or individuals) wishing to enter Laser Control Area

8. Laser Safety Eyewear:

Manufacturer	Wavelength Protection	Optical Densities

**Laser Principal Investigator Affirmations**

*By signing below, I certify that the information provided is correct to the best of my knowledge. I understand that my ability to use lasers is contingent upon approval of the Laser Safety Committee (LSC). I also understand that I must continually comply with ANSI Z136.1 laser standards to maintain LSC approval. The required forms (LF-1 and LS-1) and SOPs are attached.*

Principal Investigator (PI) Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Approvals**



Approval Recommended (LSC): \_\_\_\_\_ Date: \_\_\_\_\_

Approval Granted (LSC Chair): \_\_\_\_\_ Date: \_\_\_\_\_



# **Appendix B:**

## **Laser Hazard Signs and Warning Labels**

**Class 3B “Warning” Laser Controlled Area**

 <h1 style="margin: 0;">WARNING</h1>																	
	<p><b>Class 3B Laser Controlled Area</b>                  Restricted Area, Authorized Personnel Only</p> <p>Avoid Eye or Skin Exposure to Direct or Scattered Radiation</p> <p>Do Not Enter When Light is Illuminated</p> <p>Knock Before Entering</p> <p>Laser Eye Protection Required:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Type</th> <th style="width: 20%;">Wavelength</th> <th style="width: 30%;">Maximum Average Power</th> <th style="width: 35%;">Minimum OD</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> <p style="font-size: small; text-align: center;">Phone Number for Laser Safety Officer: 765-494-6371</p>	Type	Wavelength	Maximum Average Power	Minimum OD												
Type	Wavelength	Maximum Average Power	Minimum OD														

**Class 4 “Danger” Laser Controlled Area**

 <h1 style="margin: 0;">DANGER</h1>																	
	<p><b>Class 4 Laser Controlled Area</b>                  Avoid Eye or Skin Exposure to Direct or Scattered Radiation</p> <p>Invisible Laser Radiation</p> <p>Restricted Area, Authorized Personnel Only</p> <p>Laser Eye Protection Required:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Type</th> <th style="width: 20%;">Wavelength</th> <th style="width: 30%;">Operating Parameters</th> <th style="width: 35%;">Minimum OD</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> <p style="font-size: small; text-align: center;">Phone Number for Laser Safety Officer: 765-494-6371</p>	Type	Wavelength	Operating Parameters	Minimum OD												
Type	Wavelength	Operating Parameters	Minimum OD														



# Appendix C:

## Summary of Changes

### December 20, 2023

This document has been revised to:

- Incorporate guidance from the new ANSI Z136.1-2022 American National Standard for Safe Use of Lasers
- Update staff contact information
- Provide samples of updated laser safety forms LF-1, LS-1, and LU-1
- Update references to Radiological and Environmental Management (REM) to Environmental Health and Safety (EHS) to reflect our name change