


**National High Magnetic Field Laboratory Safety Program**

<b>TITLE:</b> Laser Safety Program	<b>SUBJECT:</b> The safe use of lasers and laser systems
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**Overall Mission and Overview:**

The National High Magnetic Field Laboratory (MagLab) Environmental, Health, and Safety (EHS) program’s mission is to:

Provide support and guidance to all MagLab departments with the implementation, maintenance, and review of a comprehensive environmental, health, and safety program. The primary goal of the MagLab EHS program is to control, reduce or eliminate work-related injuries, illnesses, and loss of MagLab resources.

The MagLab is charged by the National Science Foundation (NSF) to safely:

- Promote magnet-related research to serve an interdisciplinary scientific user community.
- Provide unique high-magnetic-field facilities through a competitive and transparent proposal review process.
- Advance magnet and magnet-related technology.
- Partner with universities, other national laboratories, and industry to enhance national competitiveness in magnet and related technologies.
- Serve the NSF as a prominent example of its successful stewardship of large research facilities.
- Support science and technology education in the United States.
- Increase diversity in the science, technology, engineering, and mathematics workforce
- Promote collaboration among our three partner institutions: Florida State University (FSU), the University of Florida (UF) and Los Alamos National Laboratory (LANL).

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## 1.0 PURPOSE

The primary purpose of the MagLab Laser Safety Program is to ensure that no laser radiation more than the Maximum Permissible Exposure (MPE) limit reaches the human eye or skin. In addition, the program is designed to ensure adequate protection against non-beam (collateral) hazards that can be associated with lasers. Non-beam hazards include the risk of electrical shock, explosion, fire, and personal exposure to harmful chemical or biological hazards. To control these hazards, the MagLab Laser Safety Program follows the safety guidelines established by the American National Standards Institute (ANSI).

- Standard Z136.1: American National Standard for the Safe Use of Lasers.
- Standard Z136.5: American National Standard for the Safe Use of Lasers in Educational Institutions.
- Standard 136.8: American National Standard for Safe Use of Lasers in Research, Development and Testing.

## 2.0 SCOPE

This Laser Safety Program establishes the requirements to be observed by all personnel at the MagLab when operating lasers or laser systems during experimentation and research. In addition, the program assigns responsibilities, provides safety guidance, and defines actions to be taken to protect workers from the hazards involved with the use of lasers and laser systems.

## 3.0 POLICY

The policy of the MagLab is to provide and maintain a safe and healthful working environment. Employees and users alike shall assist in ensuring that safety is not compromised. The safety and health of employees and users is the inherent responsibility of each employee, user, and management at all levels of supervision.

## 4.0 REFERENCES

### **ANSI Standards:**

The principal laser safety guidelines in the United States are the consensus standards drafted by the American National Standards Institute (ANSI), Committee Z-136. These include the primary standard codes ANSI Z-136.1, ANSI Z-136.5 and ANSI Z-136.8

**Federal Laser Performance Standard:**

The basic hazard classification concept was incorporated into federal government regulation issued by the Food and Drug Administration. This standard is found in the Code of Federal Regulations, Title 21, Part 1040.10. This regulation applies to manufacturers of laser products and requires them to minimize hazardous exposure by incorporating certain safety features into all laser products.

**Florida Department of Health:**

The State of Florida has also incorporated laser safety regulations into the Florida Administrative Code (FAC). These regulations are found in FAC, Chapter 64E-4, Control of Non-Ionizing Radiation Hazards. The State of Florida Laser Safety Program is administered through the Florida Department of Health (FL DOH). Florida State University (FSU) is subject to inspection and review by FL DOH personnel. If a FL DOH inspection demonstrates that FSU is not in compliance with state regulations, the University may be fined, or in the case of a serious infraction, laser use will be suspended or revoked.

**5.0 DEFINITIONS, CLASSIFICATIONS AND ACRONYMS****Classifications of Lasers are as follows:**

**Class 1:** This class is eye-safe under all operating conditions. A Class 1 laser is safe for use under all reasonably anticipated conditions of use; in other words, it is not expected that the MPE can be exceeded.

**Class 1 Product:** This is a laser product or device which may include lasers of a higher class whose beams are confined within a suitable enclosure so that access to laser radiation is physically prevented. Such products do not require a laser warning label on the exterior. An example is a laser printer.

**Class 1M:** This class is safe for viewing directly with the naked eye but may be hazardous to view with the aid of optical instruments. 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 (such as those used in open-beam telecommunications systems). Class 1M lasers produce large-diameter beams, or beams that are divergent. The MPE for a Class 1M laser cannot normally be exceeded unless focusing or imaging optics are used to narrow down the beam. If the beam is refocused, the hazard of Class 1M lasers may be increased, and the product class may be changed.

**Class 2:** A Class 2 laser emits in the visible region (400-700nm). It is presumed that the natural aversion response to the very bright light will be sufficient to prevent damaging exposure, although prolonged viewing may be dangerous.

**Class 2M:** These are visible lasers. This class is safe for accidental viewing with the naked eye, as long as the natural aversion response is not overcome as with Class 2, but may be hazardous (even for accidental viewing) when viewed with the aid of optical instruments, as with class 1M.

**Class 3R:** A Class 3R laser is a continuous wave laser, which may produce up to five times the emission limit for Class 1, or Class 2 lasers. Although the MPE can be exceeded, the risk of injury is low. The laser can produce no more than 5 mW in the visible region.

**Class 3B:** A Class 3B laser produces light of intensity such that the MPE for eye exposure may be exceeded and direct viewing of the beam is potentially serious. Diffuse radiation (i.e., that which is scattered from a diffusing surface) should not be hazardous.

**Class 4:** This is the highest class of laser radiation. These are always hazardous to view, may cause devastating and permanent eye damage, may have sufficient energy to ignite materials, and may cause significant skin damage. Exposure of the eye or skin to both the direct laser beam and to scattered beams, even those produced by reflection from diffusing surfaces, must always be avoided. In addition, they may pose a fire risk and may generate hazardous fumes.

#### **Definitions and acronyms:**

**Control Disconnect:** Any device which will turn off the laser or terminate the beam. The laser power supply can serve as a control disconnect if it is located outside the controlled area.

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

**Facility:** Any location where one or more lasers or laser systems are used or operated.

**Incident:** An event or occurrence, which results in real or suspected accidental exposure to laser radiation, that caused or is likely to cause biological damage.

**Intrabeam Viewing:** The viewing condition whereby the eye is exposed to all or part of a laser beam.

**Ionizing Radiation:** Radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization in the medium through which it passes.

**Laboratory Laser Safety Officer (LLSO):** The Principal Investigator or his/her designee will serve as LLSO for the laser lab under their supervision.

**Laser:** A device that produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.

**Laser Controlled Area (LCA)** a laser use area where the occupancy and activity of those within is controlled and supervised to prevent exposure to potentially hazardous laser radiation from Class 3b and Class 4 lasers.

**Laser Operator (LO):** Any person who actively engages in the operations of a laser or laser system, including the installation, aligning, and firing of a laser or laser system.

**Laser System:** An assembly of electrical, mechanical, and optical components that include a laser.

**Laser Use Area:** An area in which laser operation occurs and therefore safety requirements are met, and regulations are implemented. Lasers operated within a laser use area may vary and will fall under the Class 1 and Class 3R. Laser use areas using Class 3B and Class 4 laser systems will be defined under Laser Controlled Area.

**MagLab Laser Safety Officer (MagLab LSO):** One who has authority to monitor and enforce the control of laser hazards and effect the knowledgeable, evaluation and control of laser hazards. The MagLab will designate an LSO to liaison with the University's Laser Safety Officer to fulfill the LSO responsibilities for the MagLab.

**Maximum Permissible Exposure (MPE):** The level of laser radiation to which a person may be exposed to without hazardous effects or adverse biological changes in the eye or skin.

**Nominal Hazard Zone (NHZ):** The nominal hazard zone describes the space within which the level of the direct, reflected, or scattered radiation during operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the applicable MPE.

**Protective Housing:** An enclosure that surrounds the laser or laser system that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing.

**Spectator:** An individual who wishes to observe or watch a laser or laser system in operation, and who may lack the appropriate laser safety training.

**Specular Reflection:** A mirror like reflection.

**University Laser Safety Officer (LSO):** The University's Laser Safety Officer has the ultimate responsibility for providing oversight for all laser use at Florida State University.

**Wavelength:** The distance between two successive points on a periodic wave which have the same phase.

## 6.0 ROLES AND RESPONSIBILITIES

**Principal Investigator (PI):** Is responsible for the safe use of lasers in the PI's laboratory. The PI must notify the Safety Office upon purchasing a class 3B or 4 laser devices. The PI must notify the Safety Office of any changes in the operational status, such as location changes and or modifications to any laser equipment that may change the classification number. The PI may assign each laser facility a Laboratory Laser Safety Officer (LLSO) who has the proper training and background to perform this function or the PI will be the default LLSO.

The LLSO is responsible for:

- Coordinating with the Safety Department to ensuring the proper registration of all class 3B & 4 lasers and personnel who will operate the them.
- Ensuring that all personnel that work in their area have completed the online Laser Safety Training.
- Ensuring that prior to authorizing access to lasers under their control to any users that the users have received training on the specific operating procedure and have demonstrated a level of operational competency on how to safely use the laser.
- Developing, maintaining, and updating, as needed, all operating, alignment, and emergency procedures (SOP's) for the lasers and facility under the LLSO's control.
- Acting as the contact for the Safety Department.
- Enforcing the safety standards defined in the MagLab Laser Safety Program.
- Supervising all spectators, visitors, and personnel with access to their facility to ensure against unauthorized entrance or accidental exposure to laser radiation.
- Updating all records to reflect changes in personnel or equipment by contacting the Safety Department.
- Reporting all incidents involving safety violations or injury to the Safety Department at 855-SAFEMAG (723-3624).
- Ensuring that all personal protective equipment in the laser area is properly maintained.

**Individual User (Laser Operator):** Shall observe all safety precautions and operating procedures while using lasers and shall inform the PI, LLSO and MagLab Safety Department of any apparent safety problems associated with the use of the laser. Each Laser Operator shall be adequately trained as defined in this procedure.

The Laser Operator shall be responsible for:

- Following laboratory administrative, alignment and SOP's while operating lasers and reading safety instructions in laser equipment operator's manuals.
- Keeping the PI fully informed of any needed departure from established safety procedures prior to proceeding. This includes notification of an exposure incident.
- Taking the MagLab online Laser Safety Training Course and completing on the job training prior to performing any use of a laser.

**Florida State University's Environmental Health and Safety Office:** has a designated University **Laser Safety Officer (LSO)** to coordinate compliance efforts with chapter 64E-4, FAC.

The MagLab will designate a member of the Safety Team to be the **MagLab Laser Safety Officer (MagLab LSO)**. This person will work with the University's LSO to fulfill the LSO responsibilities for the MagLab. The MagLab LSO has jurisdiction over all aspects of hazard prevention and control of laser radiation at the MagLab and has the authority to suspend any operation that constitutes a radiation health hazard to the equipment operators, MagLab personnel, or the public. The MagLab LSO in conjunction with the University LSO will have the following responsibilities at the MagLab:

- Conduct annual lab inspections to ensure that safety requirements are followed.
- Review and submit all laser SOP's to the Laser Safety Committee for review.
- Authorize laser lab use areas.
- Assist in evaluating and controlling hazards.
- Update the Laser Safety Manual when necessary.
- Maintain training records.
- Ensure the provision of laser safety training for personnel who are assigned to an area where lasers are operated.
- Participate in accident investigations involving lasers.
- Coordinate with the Chair of the Laser Safety Committee (LSC) to hold Semi-annual LSC's.



**Laser Safety Committee (LSC):** The LSC is responsible for laser protection oversight at the MagLab. This is done through establishing policies, procedures, and guidance for the control of laser hazards. The LSC members are MagLab PI's that maintain laser systems and the University

The LSC is responsible for the following:

- **Policy and Procedures:** The LSC reviews internal policies and procedures to ensure compliance with applicable regulations and standards.
- **Laser Safety Issues:** The LSC resolves conflicts and issues identified by the LSO, laser Operators or other parties.
- **Authority:** The LSC and the LSO have the authority to suspend, restrict or terminate the operation of a laser or laser system that presents an imminent danger or excessive hazard.

## 7.0 LASER ACQUISITIONS, REGISTRATION AND DISPOSAL

- PIs are required to notify the MagLab LSO of any decision to purchase, fabricate or otherwise acquire a Class 3B or Class 4 laser. The LSO will review with the PI the hazards of the proposed operation and make recommendations regarding the specific safety requirements that pertain to the proposed use of the laser system.
- All class 3B and Class 4 lasers shall be properly registered with the University Laser Officer. The MagLab LSO will assist with the registration process.
- All newly registered lasers and facilities must be inspected and approved for operation by the University's and MagLab LSO prior to beginning laser operations.
- Contact the LSO before transferring or disposing of Class 3B and Class 4 lasers.

## 8.0 PERSONAL PROTECTIVE EQUIPMENT

Enclosure of the laser equipment or beam path is the preferred method of control since the enclosure will isolate or minimize the hazard. Personal protective equipment is necessary when these control measures do not provide adequate protection from the direct or reflected beams.

### **Protective Eyewear:**

Even if you are wearing protective eyewear, never look directly into any laser beam. Always use engineering controls (example, enclosing the entire beam path) whenever possible to eliminate the need for laser protective eyewear. Wear approved laser protective eyewear specifically designed for the type of laser to be used whenever working in a class 3B or Class 4 laser-

controlled areas. Even when the accessible radiation levels are considered safe, it is always good practice for laser personnel to wear eye protection when operating lasers.

Laser eyewear should not be subjected to high-intensity beams. High average intensity and high peak intensity beams can physically damage the lenses, resulting in loss of eye protection.

Protective eyewear devices shall meet the following requirements:

- Provide a comfortable fit all around the area of the eye
- Provide adequate visibility (luminous transmission)
- Be in proper condition to ensure the optical filters and holder provide the required optical density (OD) or greater at the desired wavelengths and retain all protective properties during its use
- All protective eyewear must be clearly labeled with the OD and wavelength for which the protection is afforded

### **Care and Maintenance:**

The proper care and maintenance are essential to ensure that the equipment remains in good condition. Eyewear can represent a significant investment and will last longer and give better service if it is kept clean and properly stored. Eyewear should be stored in a clean and sanitary condition in an area away from dust, dirt, and other contaminants. If the eyewear needs to be cleaned, follow the recommendations of the manufacturer. Generally, a mild soap solution is fine for polycarbonate eyewear. Special care may be needed for coated or laminated eyewear. Avoid storing in direct sunlight and protect from chemical exposures.

### **Inspection:**

Eyewear inspections shall be conducted at a minimum interval of 6 months and documented (see Appendix E) in each laboratory SOPs. Best practice states inspection of eyewear prior to each use. The inspection must include the filter material for pitting or cracking and the goggle frame for mechanical integrity and light leaks. The frame and straps should be inspected and replaced if they have been stretched or are frayed. Damaged eyewear shall be discarded and replaced. Protective eyewear shall be stored to prevent damage to the lenses and frames.

### **Skin Protection:**

When there is a possibility of exposure to laser radiation greater than the MPE for skin, Laser Operators are required to use protective gloves, clothing, and shields.

## 9.0 SAFETY TRAINING

Laser Operators (LO) who operate a Class 3B or 4 laser or laser system shall:

- Read this Laser Safety Program Manual
- Read all relevant SOP's
- Read all manufacturer supplied safety instructions for relevant laser systems
- Receive Core Laser Safety on-the-job (OJT) training on the specific laser equipment.
- Document Core Laser Safety on-the-job (OJT) training
- Take the Laser Safety training online course.

Laser Operators (LO) shall be thoroughly knowledgeable in the safe use of laser systems and understand these safety fundamentals, hazards, and controls.

- Fundamentals of laser operation
- Bio effects of laser radiation on the eye and skin
- Relations of specular and diffuse reflections
- Non-beam hazards
- Laser and laser system classifications
- Control measures
- Protective equipment
- How to handle and report accidents
- Overall management and employee responsibilities

Because of the hazard of electrocution, it is recommended that laser lab personnel take courses in cardiopulmonary resuscitation (CPR) and in the proper rescue techniques to follow in the event of electrocution. All laser service personnel, research personnel and their assistants working with high voltages should be trained in CPR.

The MagLab LSO will develop and administer the safety training programs for all personnel using Class 3B & class 4 laser systems as well as area specific laser training. Also, the MagLab LSO shall take a certified course: Laser Safety Officer with Hazard Analysis Training.

Personnel that work with lasers shall receive training prior to the assignment to work with lasers or laser systems. A refresher training program will be required every 2 years. The laser training program is offered online and emphasizes the general safety aspects of laser use, including safe work practices, engineering controls, personal protective equipment, and accident reporting.

The PI, LLSO or designee shall provide documented, on the job laser training, on the safety use and operation of lasers in their area. Incidental personnel at limited risk to an exposure may receive training on awareness and avoidance of areas containing lasers or laser system.

## **10.0 OPERATION, MAINTENANCE AND SERVICE**

Principal Investigator or his/her designee shall be responsible for arranging for maintenance and service.

Maintenance and service of lasers and laser systems shall be performed by authorized maintenance personnel for all classes of lasers.

It is important to distinguish between operation, maintenance and service when considering control measures. Lasers and laser systems are classified based on the level of accessible laser radiation during normal operation. Maintenance tasks are performed to support routine performance of the laser or laser system, such as cleaning and replenishing expendables. Maintenance tasks may or may not involve access to the beam. Service occurs less frequently than maintenance and often requires access to the beam. Service tasks include replacing laser resonator mirrors and replacing or repairing faulty components.

## **11.0 POSTING LASER USE AREAS:**

### **Laser Warning Signs:**

An illuminated warning sign shall be posted near the entrance to any laser-controlled area or laboratory that contains a Class 3B or Class 4 laser or laser system.

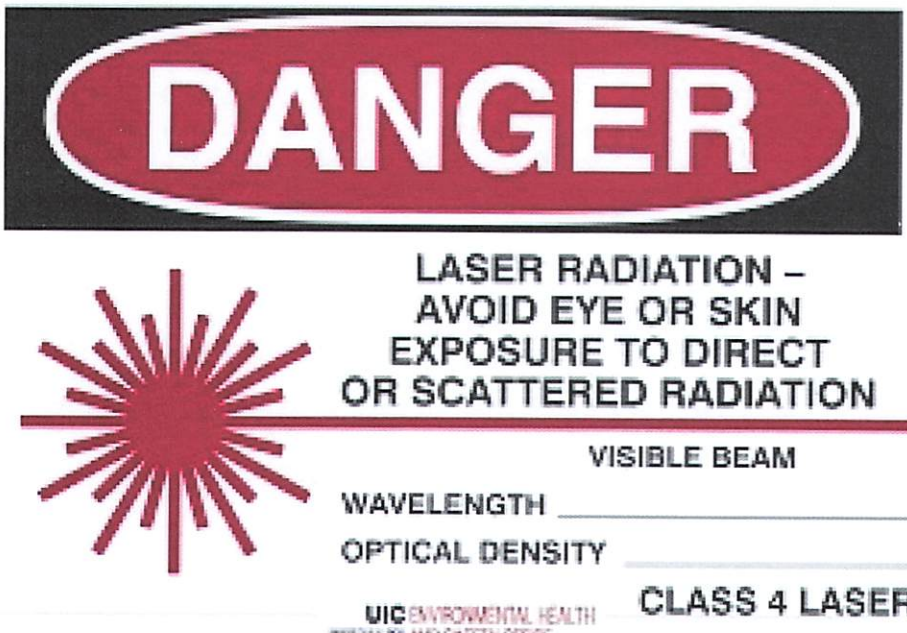
Warning lights alone do not suffice as adequate warning unless the light is clearly posted as to its meaning. The light should be activated only when the laser is on.

In accordance with ANSI Z136.1, an area which contains a Class 3B or Class 4 laser system shall be posted with an appropriate illuminated caution sign. (See example below)



**Danger:** Shall be used with all signs and labels associated with a Class 3B or Class 4 laser system.

In accordance with ANSI Z136.1, an area which contains a Class 3B or Class 4 laser system shall be posted with an appropriate warning sign. (See example below)



**Notice:** Shall be used in accordance with ANSI Z136.1, when a Class 3B or Class 4 laser is active, and all personnel leave the room, a notice shall be posted with the controlled area emergency contact information. (See example below)



**Temporary Laser Controlled Area Signs:**

Post a notice sign outside any area or laboratory designated as a temporary laser-controlled area. Temporary laser-controlled areas are required when accessible laser radiation exceeds the acceptable MPE. Use wording that describes the required precautionary procedures.

**Equipment Labels:**

All lasers, except Class I, are required to contain warning labels in accordance with the Federal Laser Product Performance Standard. Labels shall contain the laser sunburst logo and the appropriate cautionary statement. Manufacturers place these labels on laser equipment, and it is important that they are not removed.

**12.0 GENERAL SAFETY RULES**

**The general safety rules listed below must be followed by all laser personnel, visitors, users, and spectators to ensure maximum safety.**

- Education and training shall be provided for all laser personnel prior to assignment to working with a laser or laser system.
- A Temporary Work Authorization (Appendix A) form must be completed and signed by the PI, LLSO and MagLab LSO prior to performing laser work in any non-approved laser area.

- Lasers should be operated in well lighted areas when possible. If not possible, safety measures shall be taken to ensure the safety of the personnel in the area. This may include the use of glowing light switches, flashlights, training, and lighted exit signs to facilitate evacuation in the event of an emergency.
- Laser Alignment Guidelines:
  - 1) Only persons authorized by the LLSO shall perform alignment operations.
  - 2) Visual alignment shall be done with appropriate laser alignment goggles or the laser should be powered down to the lowest practical level during alignment.
  - 3) If unable to power down the laser or laser system, appropriate control measures and personal protective equipment shall be utilized.
  - 4) During alignment, the primary beam, or a specular or diffuse reflection of a beam, shall not expose the eye to a level above the MPE.
  - 5) Use low-power visible lasers for path simulation of higher power visible or invisible lasers whenever possible.
  - 6) Be sure all beams and reflections are properly terminated before high-power operation.
  - 7) Do not look directly into a laser beam at any time.
  - 8) Ensure that all beams and reflections are kept within the boundary of the laser table.
  - 9) Flash lamps used with solid state lasers should be shielded.
  - 10) Utilize beam shutters or caps when laser transmission is not required.
  - 11) Servicing of lasers and laser systems must be performed by qualified staff only.

### **13.0 CLASS 3B & CLASS 4 LASER REQUIREMENTS**

Control measures for Class 3B and Class 4 lasers are designed to reduce the possibility of eye and skin exposure to hazardous levels of radiation and to other hazards associated with laser systems. Laser control measures are designed to ensure that skin and eye exposures do not exceed the applicable maximum permissible exposure (MPE) limit. The MPE defines the maximum safe exposure without hazardous effects or adverse biological changes in the eye or skin. The MPE depends on the wavelength and exposure duration.

An important consideration when implementing control measures is to distinguish between operation, maintenance, and service. Control measures are based on normal operation of the laser system. When either maintenance or service is performed, it is often necessary to implement additional control measures.

Control measures are classified into two groups: engineering control measures and administrative and procedural control measures.

- Engineering control measures are incorporated into the laser system and the laser laboratory.
- Administrative and procedural controls are methods or instructions that specify rules and work practices to supplement engineering controls. When feasible, engineering controls are always the preferred method to provide for safety in a laser laboratory.

#### **Class 3B Lasers:**

- Use proper laser eyewear if there is a chance that the beam or a hazardous specular reflection will expose the eyes.
- Avoid placement of unprotected eye along or near the beam axis.
- Assure that individual do not look directly into a laser bear with optical instruments without adequate protective filters.
- Eliminate unnecessary specular (mirror-like) surfaces from the vicinity of the laser beam path or avoid aiming at such surfaces.
- Do not aim the beam at doorways or windows.

#### **Class 4 Lasers:**

**In addition to the Class 3B requirements Class 4 laser facilities should meet the following criteria:**

- Each area must be under the direct supervision of the LLSO.
- Access to the area must be supervised. The entrance to the doors must always be closed. There should be a barrier between the door and laser area.
- The area must have appropriate signs posted.
- Jewelry shall not be worn while operating lasers.
- All potentially hazardous beams in the area must be terminated in an appropriate beam stop.
- All optical paths that can allow the beam to exit the controlled area must be covered or restricted in a manner that prevents transmission of laser radiation.
- If a beam is to exit the controlled area, the LLSO shall ensure the beam path is limited to controlled air space.
- Protective eyewear designed for the specific laser being used must be worn by all individuals having access to Class 3B or Class 4 laser radiation during operation.
- Since viewing portals and collecting optics may increase the hazards, all devices must incorporate a means to maintain laser radiation emitted through them at or below safe levels. The Laboratory LSO shall determine the potential hazard and take proper safety measures.



- Beam stops or attenuators must be permanently attached and capable of preventing output emission when the laser is on standby.
- If at all possible, the interaction area, that is the area where the primary beam or secondary beam irradiates the sample material, should be enclosed and equipped with a safety interlock so that the laser cannot be operated unless the interlock is in place.
- If possible, Class 4 lasers with exposed beam paths should be fired remotely.
- If any engineering controls listed above cannot be accomplished, or will impede the nature of the research, administrative controls should be formulated by the PI and submitted to the LSPC for approval. These administrative controls shall be part of a SOP or Temporary Work Area controls.

#### 14.0 NON-BEAM HAZARDS

While beam hazards are the most prominent laser hazards, other hazards pose equal or possibly greater risk of injury or death. These hazards must be addressed when working with lasers.

##### **Electrical:**

Accidental electrocution while working with high voltage sections of laser systems can be lethal. Electrical hazards are not normally present during laser operation, but great care should always be exercised during installation, maintenance, or service. Laser Operators must ensure that high voltage electrodes are not exposed and that capacitors are correctly discharged. Some laser systems incorporate the use of a water-cooling system. The combination of water and electrical hazards greatly increases the risk of serious injury. Systems that permit access to components at lethal levels must be interlocked. Even though a system may be interlocked, electrical components often become exposed or accessible during maintenance and alignment procedures. This has caused numerous serious and some fatal shocks.

##### **Chemical:**

In some laser systems, dyes are used as the optically active medium. Laser dyes are often toxic, carcinogenic, and/or corrosive chemicals that are dissolved in flammable solvents. This creates the potential for personal chemical exposures, fires, and hazardous spills. Frequently, the most hazardous aspect of a laser operation is the mixing of chemicals that make up the laser dye. A safety data sheet (SDS) should accompany any chemical handled in the laser laboratory. The SDS will supply appropriate information pertaining to the toxicity, personal protective equipment needed and storage requirements of hazardous chemicals.

##### **Laser Generated Air Contaminants (LGAC):**

Air contaminants may be generated when certain Class 3B and Class 4 laser beams interact with matter. These contaminants may be toxic, corrosive, or flammable gases, dusts, mists, or vapors. The LSO shall ensure that the industrial hygiene aspects of exposure to LGAC are addressed and that appropriate control measures are affected. Engineering controls shall be used to eliminate the hazards caused from LGAC. Other control measures include the use of respiratory protective equipment and isolation of the system.

### **Cryogenic Gases and Coolants:**

Other hazards to be considered with the use of lasers and laser systems include the use of cryogenic gases as coolants, the use of compressed gases, the toxicity and reactivity of the target material, noise levels generated, and arc of the filament lamps. Controls to mitigate these hazards shall be reviewed by the appropriate EHS personnel.

### **Cryogenic Fluids:**

Cryogenic fluids are used in cooling systems of certain lasers and can create hazardous situations. As these materials evaporate, they can replace the oxygen in the air, thereby creating oxygen deficient atmospheres (asphyxiation hazard). Adequate ventilation must be provided. Cryogenic fluids are potentially explosive when ice collects in valves or connectors that are not specifically designed for use with cryogenic fluids. Condensation of oxygen in liquid nitrogen presents a serious explosion hazard if the liquid oxygen contacts any organic material. While the quantities of liquid nitrogen employed are usually small, protective clothing and face shields must be used to prevent freeze burns to the skin and eyes.

### **Ionizing Radiation:**

X-rays may be produced from two main sources: high voltage vacuum tubes of laser power supplies, such as rectifiers and thyratrons, and electric discharge lasers. Any power supply that requires more than 15 kilovolts may produce enough x-rays to be a health concern.

### **UV and Visible Radiation:**

Laser discharge tubes and pump lamps may generate ultraviolet and visible radiation. The levels produced may exceed safe limits thus causing skin and eye damage.

### **Fire Hazards:**

Class 4 laser beams represent a fire hazard and under some situations it is possible that Class 3B lasers can initiate fires. Use flame retardant materials wherever applicable with all laser applications. Operators of Class 4 lasers should also be aware of the ability of unprotected wire insulation and plastic tubing to catch on fire from intense reflected or scattered beams, particularly from lasers operating at invisible wavelengths. Laser operators should become familiar with the locations of the nearest fire extinguishers.

### **Compressed and Toxic Gases:**

Hazardous gases may be used in laser applications. (example, excimer lasers use fluorine and hydrogen chloride). The SOP should contain references for the safe handling of compressed gases such as cylinder restraints, use of gas cabinets, regulators rated for the type of gas to be used, relief valve settings, and proper tubing and fittings.

## **15.0 LASER INVENTORY INSPECTIONS**

Laser inventory inspections shall be conducted annually and may coincide with the review and approval of SOPs by the MagLab LSO. The University LSO will conduct laser inventory inspections that includes the following information:

- Location
- Principal Investigator
- Type
- Manufacturer, Model and Serial Number
- Class
- Operating and Maximum Wavelength
- Max power output
- Calculated OD
- Minimum Eyewear OD

## **16.0 EMERGENCY RESPONSE PROCEDURES**

If the injury is serious, call 911 for an ambulance. Describe the injury and arrange to meet emergency personnel. Notify the MagLab Safety Office at 855-SAFEMAG (723-3624).

Report all incidents involving exposure or suspected exposure to laser radiation to the MagLab Safety Office at 855-SAFEMAG.

**17.0 APPENDIX A: Temporary Work Authorization:**

Work as described below may be performed during the stated period after all required concurrences and authorizations have been obtained.

**Effective date:**

**Expiration Date:**

**Building:** \_\_\_\_\_

**Room:** \_\_\_\_\_

*Maximum duration: two weeks*

**Work Scope** (describe work including permitted and prohibited activities, boundaries and "stop points" as appropriate):

**Controls required:**

**Personnel included in this authorization** (signature denotes verification that training in the provisions of this Temporary Work Authorization has been provided)

Work Leader \_\_\_\_\_

Name

Signature

Date

*(Work Leader is responsible for assuring that all required training, including job- and task-specific training, is provided prior to beginning work)*

\_\_\_\_\_  
Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**Concurrences and Work Authorization**

Principal Investigator Concurrence \_\_\_\_\_

Name

Signature

Date

LLSO Concurrence \_\_\_\_\_

Name

Signature

Date

MagLab LSO \_\_\_\_\_

Name

Signature

Date

## 18.0 APPENDIX B: MagLab Laser Safety Binder

All Class 3B and Class 4 lasers have significant potential to cause injury and require specific control measures.


Laser use areas where Class 3B or Class 4 lasers operate shall have a MagLab Laser Safety Binder dedicated to that Laser Controlled Area.

The MagLab Laser Safety Binder shall include these Sections:

1. **Laser Operational Safety Procedure (LOSP) form w Alignment procedures (Appendix C)**
2. **Core Laser Safety on-the-job (OJT) training form (Appendix D)**
3. **Eyewear Inspection Document (Appendix E)**
4. **Laser Warning Sign(s) (area specific - ANSI Class 3B and Class 4)**
5. **Copy of SP-21 Laser Safety Program**

**Note: The MagLab LSO can assist with compiling a Laser Safety Binder**

19.0 APPENDIX C: Laser Operational Safety Procedure (LOSP Form)

	<b>Laser Operational Safety Procedure (LOSP Form)</b>
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Contact Information					
<b>PI:</b>		<b>Office Phone:</b>		<b>After Hours:</b>	
<b>Lab LSO:</b>		<b>Office Phone:</b>		<b>After Hours:</b>	
<b>MagLab LSO:</b>	Christopher A Rodman	<b>Office Phone:</b>	850-510-8581	<b>After Hours:</b>	855-SAFEMAG
<b>Medical Emergencies &amp; Fire</b>	Call 911 for all fire and medical emergencies. Inform the dispatcher that the emergency is at Florida State University's MagLab located at 1800 East Paul Dirac Drive.				
<b>Location/Lab No.:</b>					
<b>Description of Laser Use:</b>					

Laser Inventory								
Laser Type	Laser Class	Wavelength(s) or Range (nm)	Emission	Operating Power (W)	Pulse Energy (J)	Pulse Duration (s)	Pulse Freq. (Hz)	OD
	<input type="checkbox"/> 3B <input type="checkbox"/> 4		<input type="checkbox"/> CW <input type="checkbox"/> Pulsed					
	<input type="checkbox"/> 3B <input type="checkbox"/> 4		<input type="checkbox"/> CW <input type="checkbox"/> Pulsed					
	<input type="checkbox"/> 3B <input type="checkbox"/> 4		<input type="checkbox"/> CW <input type="checkbox"/> Pulsed					
	<input type="checkbox"/> 3B <input type="checkbox"/> 4		<input type="checkbox"/> CW <input type="checkbox"/> Pulsed					

<b>Setup/Alignment Procedure</b>	<ul style="list-style-type: none"> <li>Setup procedure and protocols</li> <li>Define alignment procedures.</li> <li>All process steps for detailed alignment – Include manufacturer's protocols for alignment.</li> </ul>
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<b>Non-Beam Hazard(s) &amp; Control Measures</b>	<ul style="list-style-type: none"> <li>• Non beam and Laser-specific hazards</li> <li>• Define hazard circumstance (when hazard exists)</li> <li>• Occupational exposure hazards beyond laser light (e.g. fumes, noise, etc.).</li> </ul>
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<b>Non-Beam Hazards</b>		
Check if Applicable	Hazards	Description and Controls
<input type="checkbox"/>	Electrical Hazards	
<input type="checkbox"/>	Chemical (dyes, solvents, etc.)	
<input type="checkbox"/>	Laser Generated Air Contaminants (LGAC)	
<input type="checkbox"/>	Toxic Gases	
<input type="checkbox"/>	Cryogenics (Oxygen Deficiency Hazards)	
<input type="checkbox"/>	Fire Hazards	
<input type="checkbox"/>	Others	

<b>Laser Control Measures</b>		
Check if Applicable	Control	Description or Comments
<input type="checkbox"/>	Controlled Access Entry	
<input type="checkbox"/>	Laser Housing Interlocks	
<input type="checkbox"/>	Emergency Stop Button	

<input type="checkbox"/>	Master Switch or Key	
<input type="checkbox"/>	Beam Stops/Attenuators	
<input type="checkbox"/>	Beam Path Enclosures	
<input type="checkbox"/>	Protective Barriers	
<input type="checkbox"/>	Warning Signs	
<input type="checkbox"/>	Other Controls	

Administrative Control (process/procedure/policies)		
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<b>Laser Environment</b>	<p>Define:</p> <ul style="list-style-type: none"> <li>• Layout of the laser use area and controlled area w/ table location(s).</li> <li>• Targets and beam stops.</li> <li>• Primary beam paths (open or enclosed).</li> </ul>
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<b>Laser Eyewear</b>	<ul style="list-style-type: none"> <li>• Laser operators shall use the appropriate laser protective eyewear (have the appropriate optical density and/or reflective properties based on the wavelengths of the beams encountered, and the expected exposure conditions).</li> </ul>
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- This eyewear shall be stored in such a manner as to protect its physical integrity.
- There shall be sufficient laser protective eyewear on hand for users and expected spectators.



- Laser eye protection shall be inspected prior to each use to ensure that it is in good condition.
- The eyewear must be labeled with readable optical density & wavelength (user can label or use other means to ID eyewear).
- The eyewear will be reviewed by the LLSO during periodic audits.

Alignment eyewear is for laser adjustment work where hazardous laser radiation occurs in the visible portion of the spectrum (400-700 nm). This eyewear reduces but does not completely block the visible spectrum. It does allow the user to see the beam and therefore perform laser alignment (adjustment) activities. The alignment filters should attenuate the radiation level to a class 2-3A level

Eyewear	Wavelength	OD	Alignment	Operation
Pair #1			<input type="checkbox"/>	<input type="checkbox"/>
Pair #2			<input type="checkbox"/>	<input type="checkbox"/>
Pair #3			<input type="checkbox"/>	<input type="checkbox"/>
Pair #4			<input type="checkbox"/>	<input type="checkbox"/>
Pair #5			<input type="checkbox"/>	<input type="checkbox"/>

<b>Personnel:</b> Only those trained and authorized by the LLSO or PI are permitted to use the laser unsupervised.	Training Required: <ul style="list-style-type: none"> <li>• Online laser safety training.</li> <li>• Completed On-the-Job Training (OJT)</li> <li>• Reference OJT Form</li> </ul>
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Authorized/Trained Individuals	
Print Name	Date

**Authorized/Trained Individuals**

**Print Name**

**Date**

Print Name	Date

**20.0 APPENDIX D: Core Laser Safety On-the-Job Training (OJT) Form**

**This form must be completed prior to allowing an individual to work alone:**

All laser users at NHMFL are required to take a basic laser safety course web course. While this class is important to the general understanding of hazards, it is site specific training that will prevent most laboratory injuries. For example, Laser alignment/beam manipulation has proven to be the activity related to most laser accidents in the research setting. It presents the greatest opportunity for unplanned/ unintentional reflections onto the eye or skin. In recognition of this, only individuals with the skills and system/ hazard awareness can perform “beam on” laser manipulation and alignment work. The individuals listed below have demonstrated core laser safety skills for their work site by OJT.

**OJT is carried out by:**

- Mentoring the individual through instruction on the work process and safety steps
- Demonstrating hands on skills
- Observing the individual perform the activity
- Receiving feedback from the trainee

Room No: \_\_\_\_\_ PI: \_\_\_\_\_

Laser Class: \_\_\_\_\_ Laser Type: \_\_\_\_\_

**CORE LASER SAFETY PRINCIPALS**

1. Selection of proper eyewear
2. Checks condition of eyewear
3. Alerts others prior to turning on laser and of open beams
4. Checks for stray reflections, thoroughly
5. Blocks stray reflections
6. Demonstrate beam detection methods
7. Understand controls for different intensity levels
8. Read & Familiar with controls per SOP
9. Familiar with equipment safety features
10. Communicates with other

Task	Name of Trainee	Signature of Trainee	Name of Trainer	Signature of Trainer	Date of Task Completion
Core Laser Safety Principals					
Core Laser Safety Principals					
Core Laser Safety Principals					
Core Laser Safety Principals					

**21.0 APPENDIX E: Eyewear Inspection Document**

At intervals not to exceed 6 months, each registrant shall examine protective eyewear devices to ensure the reliability of the protective filters and integrity of the protective filter frames. Eyewear in suspicious condition shall be discarded.

**Laser Protective Eyewear Inspection (Spring Semester):**

Name of PI: \_\_\_\_\_ Date of Inspection: \_\_\_\_\_

Lab Location(s):

No.	Inspection Notes	Y	N	NA	Comments:
L01	Laser eye protection available outside nominal hazard zone?				
L02	Laser safety eyewear available in good condition?				
L03	Eyewear available with correct OD and correct wavelength?				

**Laser Protective Eyewear Inspection (Fall Semester):**

Name of PI: \_\_\_\_\_ Date of Inspection: \_\_\_\_\_

Lab Location(s):


No.	Inspection Notes	Y	N	NA	Comments:
L01	Laser eye protection available outside nominal hazard zone?				
L02	Laser safety eyewear available in good condition?				
L03	Eyewear available with correct OD and correct wavelength?				

**22.0 REVISIONS AND APPROVALS:**

**Revisions**

Date	Revision #	Section	Description
10/02/09	1	Thru out	Document was reorganized to improve readability
10/02/09	1	Thu out	Document approved as Laser Safety Program
03/25/13	2	3.1	Baseline exam for personnel working with class 4 lasers
03/25/13	2	9.6	Rewording for clarity
03/25/13	2	6.0	Refresher training changed from 3 years to 2 years
03/25/13	2	3.4	Meeting frequency changed - annually to semiannually
7/25/13	3	3.0	Update to laser classifications
7/25/13	3	Thru out	Reevaluate or remove sections that are not necessary for this procedure
7/25/13	3	Thru out	Update contact information
6/28/17	3	Thru out	Updated format to match programs
9/22/21	4	Thru out	Review and Edit Document

**Approvals**

Title	Approver	Signature
<b>MagLab Safety Director:</b>	Jeffrey Braunwart	
<b>MagLab Laser Safety Officer</b>	Chris Rodman	