

# Laser Safety Guide – UIHC

The University of Iowa

[Environmental Health & Safety](#)

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# Introduction

The UIHC Laser Safety Program provides guidance for the safe use of lasers at UIHC and helps provide for the safety of all staff that may be exposed to laser radiation.

The laser safety policy is based on standards promulgated by ANSI Z136.1 and ANSI Z136.3, and applies to all lasers and laser systems, whether purchased, leased, fabricated, or brought in for use by others.

Class 3B and 4 lasers are commonly used in medicine. These lasers are capable of causing eye injury to anyone who looks directly into the beam. Reflections alone from high-power laser beams can produce permanent eye damage. High-power laser beams can also burn exposed skin. Laser operators must be aware of other potential dangers such as fire, electrical, biological and chemical hazards.

This manual provides basic information on laser operation and safety practices, as well as UIHC policy regarding the safe use of lasers and laser systems. Beam hazards are discussed in the body of the text and non-beam or associated hazards are discussed in Appendix 1.

## 1.0 Basic Requirements

- **Laser Registration**

All Class 3B and Class 4 lasers at the UIHC must be registered with the Environmental Health and Safety (EHS). Please contact the University's Laser Safety Officer at 335-8501 prior to ordering a laser so that the unit, work area, procedures, and safety-related equipment can be evaluated prior to use of the laser. EHS will also assign a registration number for your laser system.

- **Laser Safety Training Requirements**

All Class 3B or Class 4 laser users are required to complete general laser safety training.

Environmental Health and Safety offers this training in classroom, self-study or on-line formats.

On-line training can be found at **(ToDo)**.

In addition, all laser operators must be trained on the usage of each specific laser to be used. Vendors or other qualified individual may provide this training. Records of this training must be maintained for review by the Laser Safety Officer (LSO) and/or regulatory agencies.

Before operating a Class 3B or Class 4 laser a person must:

1. Review the Laser Safety Manual and UIHC Laser Safety Policy
2. Review the laser equipment to be used including administrative requirements and applicable SOPs
3. Review the operating and safety instructions furnished by the manufacturer.
4. Utilize appropriate personal protective equipment.

## • **Responsible Parties**

Laser Safety Panel/Laser Safety Officer (LSP/LSO)

The UIHC Laser Safety Panel and Laser Safety Officer are responsible for:

- Maintaining inventory of all Class 3B and Class 4 lasers and verifying classification if necessary.
- Reviewing standard operating procedures, safety procedures and other control measures, before initial use.
- Periodically inspecting Class 3B and Class 4 lasers to assess compliance with safety requirements.
- Providing assistance in evaluating and controlling hazards.
- Maintaining records of Class 3B and Class 4 laser safety audits.
- Participating in accident investigations involving lasers.
- Suspending, restricting or terminating the operation of a laser or laser system without adequate hazard controls.

## • **Laser Operators/Ancillary Staff**

All UIHC staff involved in laser procedures shall:

- Complete all applicable requirements including training before operating a laser.
- Use lasers safely and in a manner consistent with safe laser practices, requirements and standard operating procedures.
- Maintain a safe environment/area during the operation of a laser.
- Use personal protective equipment as applicable.
- Ensure all necessary safety equipment is present and functional.
- Perform equipment performance checks prior to use as applicable.
- Periodically inspect laser and safety equipment prior to each procedure.

## • **Departmental Responsibilities**

Each department utilizing lasers shall:

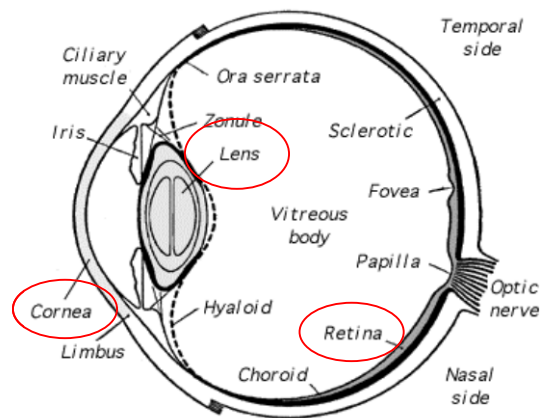
- Notify the LSP/LSO of the intent to procure a laser, and provide required information for registration and safety reviews for lasers.
- Ensure all laser users complete general laser safety training.
- Ensure that a hazard assessment for personal protective equipment (PPE) use is completed and specific PPE training is provided for all laser users for whom PPE will be required. See EOC safety policies for guidance.
- Provide laser specific training for all operators.
- Ensure lasers are operated safely and in accordance with applicable requirements.
- Provide medical surveillance for laser operators and ancillary personnel as described in Section XI, as applicable.
- Ensure that each laser is stored securely and safely when not in use so that it is not usable by unauthorized personnel or under unauthorized conditions.
- Maintain written SOPs for Class 3B (with invisible beams) and all Class 4 lasers and ensure laser use is commensurate with the requirements of the SOP.

- Inform the LSP/LSO prior to receiving a laser, transferring a laser to another user, sending a laser to another site off-campus, or disposal of a laser or laser system.
- Report any known or suspected accidents to the Laser Safety Officer/Laser Safety Panel.

## 2.0 Laser Safety Hazards

### • Beam Hazards

Intra-beam viewing of the direct beam and the specularly reflected beam are most hazardous when the secondary reflector is a flat and polished surface. Secondary reflections from rough uneven surfaces produce more diffuse reflections and are usually less hazardous. Extended source viewing of normally diffuse reflections are not normally hazardous except for very high power lasers (Class 4 lasers). Extra care should be taken with IR lasers since diffuse reflectors in the visible spectrum may reflect IR radiation differently and produce greater exposures than anticipated.



**Fig. 1 Anatomy of the Human Eye**

Laser radiation of differing wavelengths affects different portions of the eye. Refer to the diagram above as reference for the information below:

**Far and Middle Infrared** – (25,000 nm – 2500 nm) – Far infrared radiation is thermal in nature and is absorbed by the cornea. This may cause burns and loss of vision. Eye injury from middle infrared laser radiation is usually the result from heating or thermo-mechanical effects. This wavelength range penetrates deep into the lens and can cause cataracts

**Near Infrared** (2500 nm – 750 nm) and **Visible** (750 nm -400 nm) – This range of laser radiation can cause a retinal burn which could result in a permanent blind spot or even total blindness if the optic nerve is injured. These injuries can be painless, and the damage is permanent.

**Ultra-Violet** – There are two bands of ultra-violet laser radiation with respect to potential energy.

(400 nm – 315 nm) – Absorbed by the lens and may cause cataracts

(315 nm – 100 nm) – Absorbed by the cornea and may cause photokeratitis. This can be extremely painful and result in temporary vision loss.

### **Symptoms of Laser Eye Injuries –**

Visible Beam Lasers - Exposure can be detected by a color flash and an after-image of its complementary color. For example, a green 532 nm laser light would produce a green flash followed by a red after-image. When the retina is affected, there may be difficulty in detecting blue or green colors because of cone damage.

CO<sub>2</sub> (Invisible) Beam Lasers - Exposure causes a burning pain of the cornea or sclera.

- **Laser Generated Airborne Contaminants (LGAC)**

Air contaminants associated with the use of Class 3B and Class 4 lasers. In a medical setting, LGACs result from the interaction of the laser beam with tissue and can contain smoke, chemical vapors, and aerosols containing biological contaminants. Local and area ventilation must be adequate to keep airborne contaminant levels below worker exposure limits. Refer to UIHC Laser Safety Policy on controlling exposure to laser plume for more information.

**Note:** The use of surgical masks alone does not provide adequate protection against exposure to LGACs.

### **Other Non-Beam Hazards**

Certain types of lasers can produce non-beam hazards such as electrical shock, hazardous chemical exposure, and collateral radiation. For a description of these hazards, please refer to Appendix 1.

Risk of skin injury can be significant when working with high power infrared lasers or lasers which emit in the ultraviolet spectral region. Risks from infrared lasers include thermal burns and blistering or charring of the skin. Risks from UV lasers include sunburn, skin cancer, skin aging and photosensitization.

## **3.0 Laser Safety Practices**

The following measures are recommended as a guide to safe laser use. Some additional measures may be required for specific laser classes and lasers that emit invisible radiation. See ANSI Z136.1 and Z136.3 for more details, or contact the Laser Safety Officer at 5-8501 for additional information.

- **Work Area Safety Practices**

- Area entryway controls must be in place in order to minimize potential for injury. The proper warning signs shall be posted.
- Fire safety equipment shall be readily available.
- Ensure operation of local and area ventilation systems where applicable.
- The laser should be used such that the beam path is above or below normal eye level (below 4.5 ft. or above 6.5 ft.) if possible
- The potential for specular reflections should be minimized by removal of all unnecessary reflective surfaces.
- Windows to hallways or other outside areas must be provided with adequate barriers or covers when necessary to keep the Nominal Hazard Zone (NHZ) within the room.
- The active laser never should be left unattended.
- Warning devices must be installed for lasers with invisible beams to warn of operation.
- The use of non-flammable materials and non-flammable anesthesia is vital.
- The beam should never be activated unless directed toward target tissue.
- A fire extinguisher or pan of water must be within close proximity to the laser procedure room. Please note that water should never be used on or near an electrical device.

- **Laser Use Safety Practices**

- Perform a laser system safety check prior to each case.
- Utilize a laser operator in addition to the physician using the laser.
- Avoid looking into the primary beam at all times.
- Do not aim the laser with the eye; direct reflections could cause retinal damage.
- Clear all personnel from the anticipated path of the beam.
- Before operating the laser, warn all personnel of the potential hazard, and ensure all safety measures are satisfied.
- Be very cautious around lasers that operate at wavelengths not visible to the human eye.
- Use proper eye protection when working with a Class 3B or Class 4 laser. *Remember that safety glasses provide no protection unless they are worn. Safety glass lenses may shatter or melt when the lens specifications are exceeded. Scratched or pitted lenses may afford no protection. Frequent inspection of protective eyewear is recommended. Eye protection is specific for the type of laser and may not provide protection at laser wavelengths or power levels other than those for which they were designed. See Section IV for more details.*

## **4.0 Personnel Protective Equipment**

In addition to engineering and administrative controls, personal protective equipment for skin and/or eyes is often necessary when working with Class 3B or Class 4 laser systems. By OSHA regulation, all laser users required to wear personal protective equipment must undergo a hazard assessment for PPE use and must receive specific PPE training. Forms for completing each are included as Appendix 3 to this manual. Completion of these two items for each laser user is the responsibility of each department.

- **Eye Protection**

Eye protection suitable to the laser must be provided and worn within the laser control area if there is a potential for exceeding the MPE limit. Protective eyewear may include goggles, face shields, equipment filters, or prescription eyewear using special filter materials or reflective coatings. Exceptions may be



approved by the LSO if the eyewear produces a greater hazard than when the eye protection is not worn.

No single type of eyewear will provide protection against all wavelengths of laser radiation; therefore, eye protection should:

- Provide enough visibility to perform the procedure.
- Be able to withstand the maximum power of laser radiation likely to be encountered.
- Be able to absorb the specific wavelength of radiation that is being used.
- Be clearly labeled with wavelength they are designed for, the optical density at that wavelength, together with the maximum power rating.
- Be inspected periodically by the laser operator to ensure that pitting, cracking and other damage will not endanger the wearer.

Lasers that can be tuned through a range of wavelengths present special problems. Broad band laser goggles may provide the level of protection required but they must be chosen with great care. If there is any doubt regarding the suitability of a particular type of eye protection, contact the Laser Safety Officer at 335-8501 for guidance.

## • **Skin Protection**

Skin injuries from lasers primarily fall into two categories: thermal injury (burns) from acute exposure to high power laser beams and photo-chemically induced injury from chronic exposure to scattered ultraviolet laser radiation.

### • **Thermal Injuries**

- Can result from direct exposure to the direct beam or specular reflections
- Injuries can be painful but are usually not serious
- Easily prevented through proper beam management and hazard awareness

### • **Photochemical Injury**

- May result from chronic UV exposure to direct beam or specular and diffuse reflections.
- Effect can be minor to severe sunburn, increased risk of skin cancer.
- Protective clothing can help control UV skin exposure.

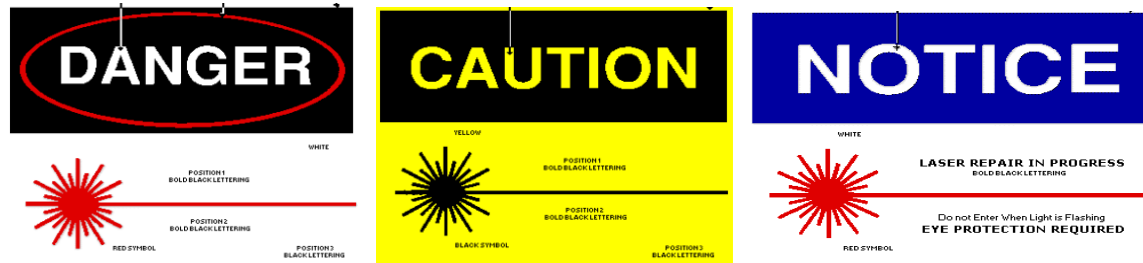
### • **Protective Clothing**

- Clothing that covers skin may be required to protect the skin for certain laser wavelengths and intensities
- High powered pulsed UV lasers are especially hazardous
- Window drapes should be used to prevent skin exposure to persons outside of the procedure room.

## **5.0 Warning Labels and Signs**

ANSI Z136.1 requires that lasers and laser systems have appropriate warning labels and that the areas in which they operate be posted with appropriate warning signs.

The figures below are examples of laser warning signs:



All lasers (except Class 1) shall have appropriate warning labels affixed to a conspicuous place on the laser housing or control panel. Laser area warning signs and equipment labels are available from EHS or a number of safety supply companies, including the [Laser Institute of America](#).

## 6.0 Laser Safety Standard Operating Procedures

Class 3B lasers and laser systems require a written procedure if:

- The laser beam produced is a wavelength invisible to the eye; or,
- The laser produces a continuous wave visible beam of more than 15 mW.

Helium-Neon lasers with 15 mW or less normally do not require a written procedure; however, all other safety requirements for this class of laser apply.

All Class 4 lasers and laser systems require a written SOP.

Laser usage SOPs should include the following information as a minimum:

- Laser operating procedures
- Laser safety-check procedures.
- Laser maintenance procedures
- Service procedures
- Alignment procedures
- A description of the Nominal Hazard Zone for each procedure.
- The use of protective eyewear and other personal protective equipment as appropriate.
- The above listed content can often be found in the operation manual supplied with the laser.

## 7.0 Laser Purchase Considerations

The UIHC Laser Safety Panel has put together the following guidance to consider during the process of acquiring a new laser or laser system:

- Try to have vendor accept old lasers on trade to avoid disposal costs
- Request enough safety glasses for all staff – Verify that they cover the appropriate wavelengths

- Request laser specific warning signs
- Request extended warranty at no additional cost
- Request in-service training for staff
- Request service manuals and service training at no additional cost
- Ensure the procedure room is equipped for laser procedures

## 8.0 Laser Disposal Guidelines

Disposal of laser systems or components should adhere to the following guidelines. The steps are listed in order of preference:

1. Trade the obsolete laser to the new laser supplier/manufacturer.
2. Obsolete laser disposal should minimize potential hazards to humans and the environment while eliminating UIHC liability.
3. Reuse the obsolete laser for other purposes within the UIHC/UI (i.e. UI Engineering, UI Med Labs.)
4. Render the obsolete laser unserviceable.
  - Use the obsolete laser components for other lasers
  - Use an outside firm to dismantle and dispose of the obsolete laser (i.e. ATEC in Des Moines charges by the pound)
5. Dispose the obsolete laser via medical equipment broker
  - Use legal (hold harmless) form
  - Transfer to "missions" or 3rd world country
6. Reuse/transfer/sell the obsolete laser for non-medical use (i.e. education, research, animals, etc...)
  - Use legal (hold harmless) form
7. Review laser disposal with the UIHC-LSO and/or Bio-Engineering. Note: Functional lasers are not to be sent to UI Surplus.

Additional things to consider when disposing of a laser include:

- Disposition of UI property tag
- The laser contains hazardous materials
- Disposition of hazardous materials
- Stored electrical energy discharge
- The laser to remain in the UI/UIHC safety jurisdiction
- The laser contains biohazards
- The laser has been decontaminated
- The laser purchaser will sign a legal (hold harmless) form
- The obsolete laser does not contain fire/explosive hazards
- Provide manuals to laser purchaser (if available)

## 9.0 Medical Surveillance and Exposure Incidents

If an exposure incident occurs, the affected individual(s) shall inform their supervisor and be referred immediately to the Worker's Health Clinic, located in Clinic A of Boyd Towers. The employee will be evaluated and/or referred for ophthalmologic assessment as appropriate. If the incident occurs outside of regular clinic hours, the employee(s) should be seen in the UIHC Emergency Treatment Center. In

addition, the employee must complete a “Worker’s Compensation First Report of Injury or Illness” form. See UIHC Laser Safety Policy for further detail.

## 10.0 References

1. American National Standard for the Safe Use of Lasers, ANSI Z136.1, 2007.
2. American National Standard for the Safe Use of Lasers in Healthcare Facilities, ANSI Z136.3, 2005.
3. University of Waterloo, Ontario, Laser Safety Manual, 2000
4. “OSHA Technical Manual – Section III, Ch. 6 Laser Hazards”, 2000
5. “UC Berkeley Laser Safety Manual”, 1998
6. “Iowa State University Laser Safety Manual,” Iowa State University, 1998.
7. “Laser and Eye Safety in the Laboratory.” Matthews, Larry. New York: IEEE Press; Bellingham, Washington. SPIE Optical Engineering Press, 1995.
8. “Safety with Lasers and Other Optical Sources”, Sliney and Wolbarscht, 1980
9. “Laser Safety and the Eye”, Lions Laser Skin Center, Vancouver, 1996
10. “Publication 3000 – Chapter 16 Lasers” Lawrence Berkeley National Lab, 1997

## Appendices

- [Appendix 1 – Non Beam Hazards](#)
- [Appendix 2 – Glossary of Terms](#)
- [Appendix 3 – UIHC Laser Safety Policy and Procedure](#)
- [Appendix 4 – UIHC Laser Smoke and Aerosol Safety Information](#)
- [Appendix 5 – UIHC Laser Safety Assessment/Audit Form](#)