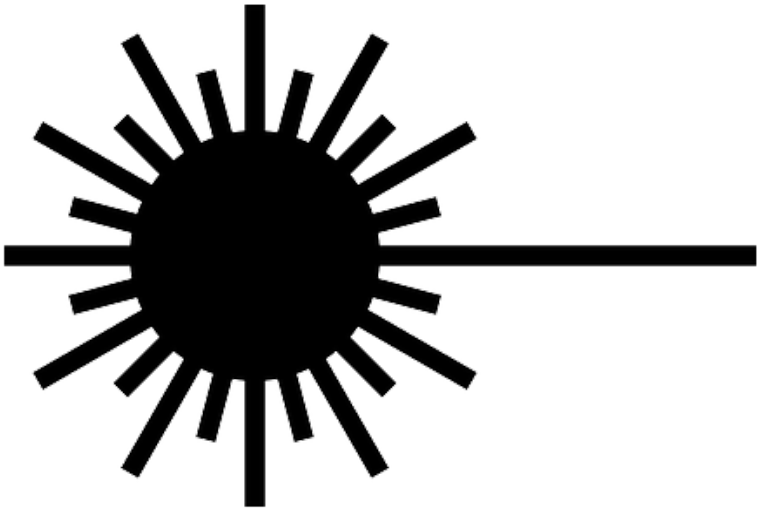
UNIVERSITY OF CENTRAL FLORIDA

LASER SAFETY MANUAL

2023 Edition



Department of Environmental Health and Safety
3512 Perseus Loop
Orlando, FL 32816
www.ehs.ucf.edu
Phone (407) 823-6300

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I. Purpose, Scope, and Applicability

The extensive use of laser equipment and continuation of a reputable nonionizing radiation program at the University of Central Florida (UCF) calls for a Laser Safety Program and the implementation of its policies. This manual states the safety requirements of the UCF Laser Safety Program. The policies and guidance contained in this program apply to all facilities under the jurisdiction of the UCF and/or within UCF that are involved in the use of lasers. The purpose of this manual is to ensure the safety of all lasers and laser equipment users.

The UCF Laser Safety Program within the Department of Environmental Health and Safety (EHS) has envisioned a safe working and learning environment for faculty, staff, researchers, students, and visitors. The program has been designed with the purpose of:

- Keeping all individuals working and learning in research and/or instructional laboratories on UCF campuses safe in regards to laser, optics, and photonics related studies;
- Upholding regulatory compliance with state and federal agencies;
- Giving safety and compliance direction and advice to Authorized Users of lasers and laser users;
- Providing instructions on the attainment, safe use, relocation, surplus, and disposal of registered lasers at the UCF;
- Offering and making known to the Authorized Users and Principal Investigators (PI) the available resources provided by EHS.

The development of an all-encompassing laser safety program is essential to maintaining a compliant environment within a large university. The benefit of implementing an effective laser safety program far outweighs its negligence, providing the institution with educated individuals who strive for wellbeing, an ever-present safety culture, an ethical environment for the campus and the surrounding community, and international integrity.

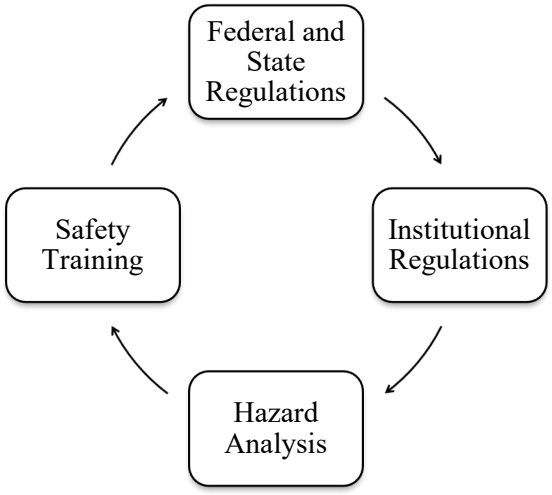


Figure 1: *UCF Laser Safety Program continuance in order to maintain compliance*

II. Regulations and Standards

Lasers have become an important research tool in many research facilities, notably in higher education. If improperly used or controlled, lasers can cause severe injuries to the operators or others, along with a potential to damage property. Laser-related injuries include blindness, burns, and electrocution. Laser-related risks can be beam and non-beam hazards, with property damage resulting from fire or chemical spills. Operators' safety and health can be affected by both beam and non-beam hazards as well.

When used improperly, some lasers can cause eye injury, coming from the direct beam and/or specular reflections. Class 4 lasers are capable of causing eye injury from diffusion reflections. These high-power beams also have the potential to burn exposed skin, ignite flammable materials, and may generate hazardous air contaminants. In addition, equipment used to produce the lasing action as well as control and direct the laser beam introduce additional hazards, such as: high voltage, high pressure, cryogenics, noise, radiation, and toxic gases. As a result, rules and regulations have been put in place to protect users and workers.

This Laser Safety Manual is a reflection of some guidelines and standards set forth by federal and state regulators, including: the *American National Standards Institute (ANSI), Committee Z-136*; the State of Florida's Laser Safety Program regulations, administered by the Florida Department of Health (FDOH), found in the Florida Administrative Code (FAC), Chapter 64E-4, *Control of Non-ionizing Radiation Hazards*; Food and Drug Administration (FDA), *Code of Federal Regulations, Title 21, Part 1040.10*; and the Occupational Health and Safety Administration (OSHA) standards.

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 entitled, *ANSI Z-136.1, Safe Use of Lasers*. This standard outlines the maximum permissible exposure (MPE) limits for laser users, defines laser hazard categories, and provides detailed information for determining the appropriate safety precautions for each laser hazard category. This standard also provides the basis for international regulation. *ANSI Z-136.8, Safe Use of Lasers in Research, Development, or Testing* provides the latest consensus guidance for laser safety in research laboratories.

Florida Department of Health Standard

The State of Florida has 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 (FDOH). UCF is subject to inspection and review by FDOH personnel. If a FDOH inspection demonstrates that UCF 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. In order to ensure compliance with state regulations for the control of laser radiation, it is essential that all personnel who uses lasers understand and follow the requirements of this manual.

Registration Requirements for Lasers

All class 3B and 4 lasers must be registered with the State of Florida, Department of Health Bureau of Radiation Control *(See Appendix H: Laser Device Registration Form, DH Form 1605)*.

Federal Laser Performance Standards

The basic hazard classification concept was incorporated into federal government regulation issued by the Food and Drug Administration (FDA). 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.

The Occupational Safety and Health Administration (OSHA) Standards

The Occupational Health and Safety Administration (OSHA) requires employers to ensure the safety of all employees in the work environment. Eye and face protection must be provided whenever necessary to protect against chemical, environmental, and radiological hazards as well as mechanical irritants.

Ensuring workers' safety includes conducting a workplace hazard assessment and providing adequate training for all workers who require eye and face protection. When employees are trained to work safely, through the following requirements, they should be able to anticipate and avoid injury from job related hazards.

III. Program Administration and Responsibilities

Laser Safety Officer

The Laser Safety Officer (LSO) is the individual who has the authority and responsibility to monitor and enforce the control of laser hazards and the knowledgeable evaluation of laser hazards. UCF has an Institutional LSO employed by EHS, and individual departments may have deputy LSOs.

Specific Duties and Responsibilities of the Institutional LSO

The LSO shall:

- Institute and uphold sufficient policies and procedures for the mitigation of laser hazards. These policies must fulfill federal, state, and local regulations.
- Maintain records of lasers and register class 3B and 4 lasers with the State of Florida.
- Correctly classify or verify classifications of lasers and laser systems.
- Conduct hazard evaluations of laser work areas on an annual basis. Periodically audit and perform re-inspections to ensure proper safety culture is established in the laser work area.
- Make certain that the recommended control measures are in effect or approve alternate ones when the primary controls are not practical.
- Approve standard operating procedures for operation and alignment of lasers ensuring that safety is the principal component.

- Accept wording and specifications on laser area signs and equipment labels.
- Approve all new or modified laser installation facilities and laser equipment prior to use.
- Ensure that acceptable safety education and training are provided to laser authorized users, workers, and students using these devices. Individuals that are not laser users, but working in labs with lasers will receive awareness training.
- Provide advice on all matters pertaining to the safe use of lasers.
- Establish and maintain a Laser Safety Committee or Laser Safety Advisory Board.
- Suspend, restrict, or terminate the operation of a laser or laser system if it is deemed not safe.
- Ensure that the necessary records, i.e. those required by government agencies, are maintained. These records may also include incident investigations and education records.
- Investigate all known or suspected accidents or near misses resulting from use of a laser.

Deputy Laser Safety Officer

Deputy Laser Safety Officer (DLSO) shall perform the functions of the Institutional LSO when he/she/they is/are not available.

Laser Safety Committee or Laser Safety Advisory Board

The Laser Safety Committee or Laser Safety Advisory Board establishes and maintains proper policies and practices for the assessment and regulation of laser hazards. This includes making recommendations on appropriate laser safety training programs and materials to the Laser Safety Program and the UCF. The committee also shall maintain an awareness of all applicable new or revised laser safety standards. At least one member of each department using Class 3B and 4 lasers shall be represented. Other members may include individuals with expertise in laser technology or in the assessment of laser hazards.

Responsibilities of the Supervisor/Principal Investigators

- Submit a Registration Form *(See Appendix D: Laser Registration Form, LS-1)* to the Institutional LSO for each Class 3B and Class 4 lasers or laser systems present in the lab(s).
- Identify unsafe conditions present in the laser work area, implement appropriate hazard controls (including ANSI approved signs and labels), and correct any identified hazardous conditions. The Supervisor/Principal Investigator (PI) shall not permit operation of a new or modified Class 3B or Class 4 laser in his possession without approval of the LSO.
- Develop and submit to the Institutional LSO the current Standard Operating Procedures (SOPs) for each Class 3B and Class 4 laser or laser system in possession *(See Appendix C: Standard Operating Procedures Template (SOP)*.
- Identify all authorized personnel who are eligible to operate or maintain a Class 3B, Class 4 laser, or a laser system. Identify laboratory workers that are non-laser users, but will be working in the laser use area.
- Require non-UCF employee who are volunteers and does not have an employment relationship with UCF to complete a Volunteer Services Agreement form. Any

volunteer under the age of 18 must have parent or guardian consent. For additional information, refer to the following UCF policies and guidelines:
    - *https://compliance.ucf.edu/enterprise-risk-management/university-volunteers/*
    - *https://policies.ucf.edu/documents/2-005.pdf*
    - *https://compliance.ucf.edu/files/2022/03/Program-Staff-Code-of-Conduct-Combined.pdf*
- Provide training for each laser user including information on the physical hazards, health hazards, and emergency procedures related to lasers specifically.
- Conduct annual self-inspections of lasers and laser use areas.
- Designate a Laser Safety Supervisor or Manager and provide the information to EHS.
- Ensure that laser users follow established safety procedures for the laser system they are working with.
- Keep copies and annually update all current SOPs and relevant training in the Laser Safety Manual.
- Maintain a copy of the Laser Safety Program in the laboratory or laser work area.

Responsibilities of the Laser User

- Know the hazards and the precautionary measures for the laser or laser system being used.
- Complete safety trainings and refresher courses required by the department and the university.
- Complete SOP training for each laser in laboratory; sign authorized user list
- Plan and conduct operations in accordance with established procedures and good safety practices.
- Use personal protective equipment and safety eyewear in correspondence to the laser system that is being used.

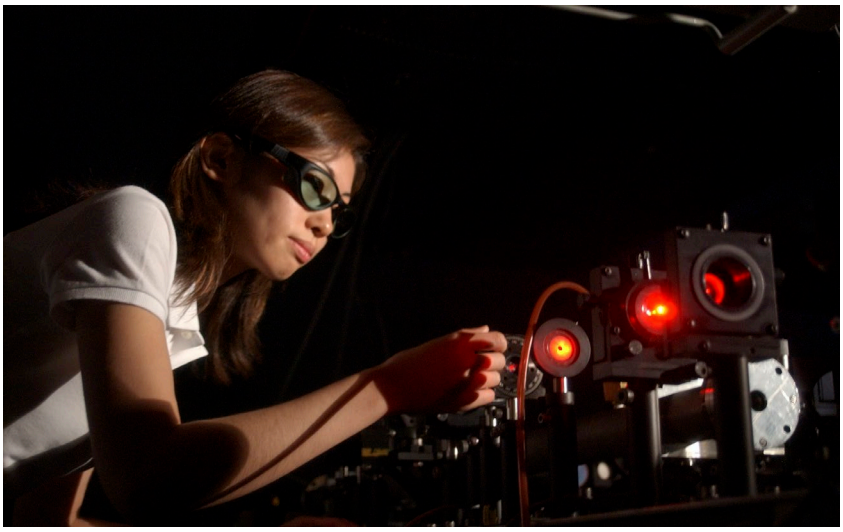
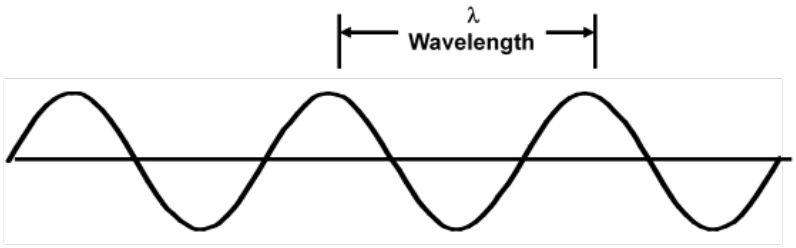


Figure 2: *CREOL Laser User, UCF*

IV. Laser Fundamentals

What is a Laser?

Laser is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. The laser is an intense light beam with a very narrow band width that can produce images by electronic impulses. Light is an electromagnetic wave consisting of oscillating electric and magnetic fields traveling through space. The wavelength is the distance between two peaks on the wave.



Different wavelengths are seen by the eye as different colors. Blue light has a wavelength of about 400 nm (0.4 mm) and red light has a wavelength of about 700 nm (0.7 mm).

Laser light has three characteristics that differ from ordinary light:

1. The **monochromatic** property of laser light means it is all one wavelength.
2. The **directional** property of laser light means that the beam spreads very slowly.
3. The **coherent** property of laser light means that all the light waves are in phase.

A laser produces coherent light with a narrow range of wavelengths, where the wavelength of the light beams determines its character. The term "radiation" in this context is used to describe an energy transfer. Energy moves from one location to another by conduction, convection, and radiation. The color of laser light is normally expressed in terms of the laser's wavelength and is expressed in nanometers (nm). Laser light is non-ionizing and includes ultra-violet (100-400nm), visible (400-700nm), and infrared (700 nm-1mm).

How does a Laser work?

A laser contains an optical cavity, a pumping system, and a laser medium (material) as illustrated in Figure 3.

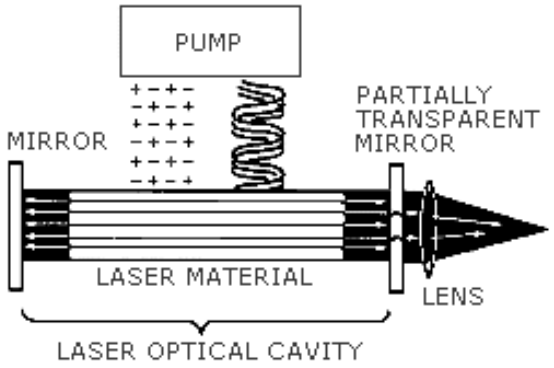


Figure 3: *Components of a Laser*

An **optical cavity** consists of the media to be excited with mirrors in order to direct the produced photons back along the same general path. The **pumping system** uses photons from another source as a xenon gas flash tube (optical pumping) to transfer energy to the media, electrical discharge within the pure gas or gas mixture media (collision pumping), or relies upon the binding energy released in chemical reactions to raise the media to the metastable or lasing state.

The **laser medium** can be a solid, gas, dye, or semiconductor. Lasers are classified by the type of lasing material present. Various laser mediums include: solid state, gas, excimer, dye lasers, and semiconductor.

Laser Beam Injuries

From a safety standpoint, the most significant result of the coherent characteristics of laser light is that laser light is focused to a very small spot by a lens. This means that laser light can be concentrated on the retina of the eye by as much as 100 times more than ordinary light. Thus, even relatively low levels of laser light can produce significant eye hazards. The anterior structures of the eye are most susceptible to damage from ultraviolet radiation. Retinal injury is the most concerning eye injury hazard when working with lasers, with visible and infrared radiation presenting the greatest hazard.

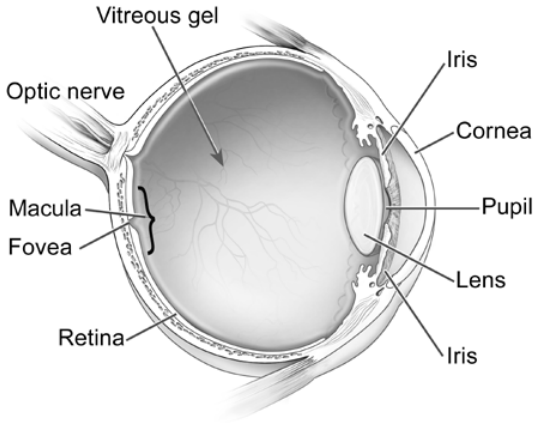


Figure 4: *Diagram of the Eye [10]*

Laser injuries result from two types of effects, thermal and photochemical.

> **Thermal** injuries are caused by heating of the tissue as a result of the absorption of laser energy. This causes proteins to be "denatured" (cooked) and results in a burn. Thermal burns can occur at all wavelengths. They are the most common injury to eyes and skin for continuous wave and long pulse lasers.
>
> Micro-cavitation is a type of thermal effect that occurs when a short laser pulse is focused onto the retina. Most of the pulse energy is absorbed in a small volume heating the water in that volume to steam. This results in a microscopic steam explosion that separates retinal layers and ruptures blood vessels in the retina. This kind of injury results in significant vision loss and is the greatest risk for short pulse visible and near infrared lasers.
>
> **Photochemical** injuries occur because high energy photons break molecular bonds inside living cells. This creates molecular fragments that are toxic and injure the cell.

It should be mentioned that most people injured by laser exposures have had no laser safety training. In most cases the errors that led to the injury were simple mistakes that could have been avoided easily with a basic knowledge of laser safety.

A number of laser accidents have occurred when beam alignment was performed without adequate safety precautions. Beam alignment should always be performed in accordance with documented alignment procedures approved by the Laser Safety Officer.

Many accidents in research laboratories have also occurred because stray reflections were not controlled. All stray reflections should be located and blocked as close to their source as possible. The laboratory should be checked routinely for new stray reflections.

The appropriate use of laser safety eyewear is a fundamental component of laser safety. In previous cases, most people injured by laser exposures had eyewear available, but were not wearing it at the time of the exposure. See Appendix A for more detailed information on laser beam hazards.

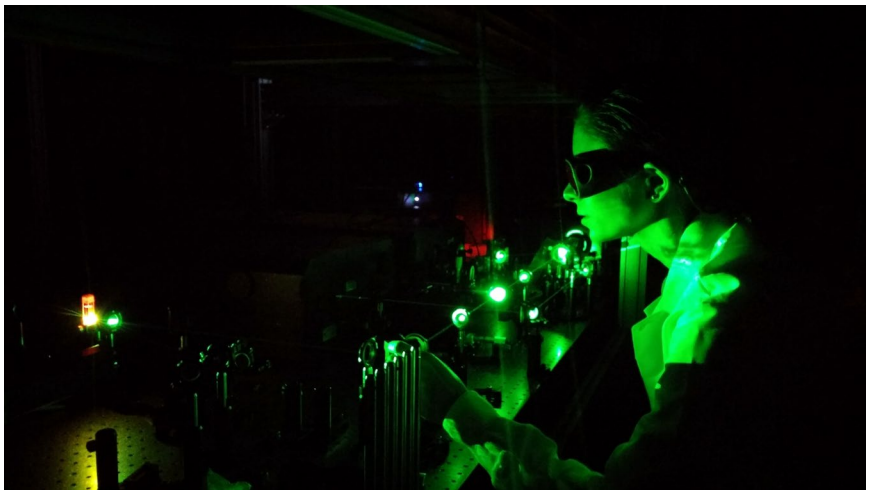


Figure 5: *Julie Donnelly, Chemistry Department Laser User*
Photograph taken by Carlos Diaz
Dr. F. Eloy Hernandez Laboratory, UCF

Non-Beam Injuries

In many cases the hazards from exposure to laser light are controlled and the greatest risk to workers is from a non-beam hazard associated with laser use. Some of these include: electrical hazards, laser-generated air contaminants (LGACs), chemical hazards, collateral radiation, and mechanical hazards. Descriptions of each of these hazards among others are provided below.

The most serious of these non-beam hazards is the electrical hazard from laser power sources. Several fatalities have occurred because of this hazard. These exposures can occur during laser set-up or installation, maintenance and service, or where the equipment protective covers are removed. Individuals must treat all electrical equipment as if it were "live" and only work on de-energized parts of electrical systems using lock out tag out procedures, insulated tools, and not wearing conductive items like watches on hands or arms. Always be aware that capacitors can accumulate residual charge after equipment is de-energized.

Chemical materials, either intended or accidental, are potential targets of lasers that can readily convert into toxic gases or aerosols and result in laser-generated air contaminants (LGACs). Examples include formation of ozone and decomposition of plastics, which can form hydrochloric acid, hydrofluoric acid, phosgene, and hydrogen cyanide. Proper ventilation is required to remove these hazardous gases from the laboratory air.

Many laser dyes are toxic, carcinogenic, corrosive, or pose a fire hazard. Check the vendor specific safety data sheet for more information pertaining to the toxicity, personal protective equipment, ventilation requirements, and storage of these chemicals.

Radiation other than associated with the primary laser beam is called collateral radiation. Examples are X-rays, ultraviolet (UV), plasma, and radio frequency emissions. High-voltage vacuum tubes of laser power supplies may produce x-rays. Laser discharge tubes and pump lamps may generate UV and visible radiation.

Trip hazards can also be a real issue in a congested and shared laboratory environment and can cause thermal injuries if lab personnel fall and a part of their body crosses the beam path. Keep aisles clear and electrical cords out of the way.

Compressed gas cylinders, if not stored and operated properly, can be a deadly and disastrous hazard. They must always be restrained with chains or stands.

V. Laser Classification

Since August 1976, manufacturers have been required by Federal law to classify lasers. If the class is not known, one can be determined by measurements and/or calculations. Lasers are classified according to the ability of the primary or reflected beam to injure the eye or skin. The appropriate class is determined from the wavelength, power output, and duration of pulse (if pulsed). Classification is based on the maximum accessible output power. There are four laser classes, with Class 1 representing the least hazardous. All lasers must be labeled with the appropriate hazard classification.

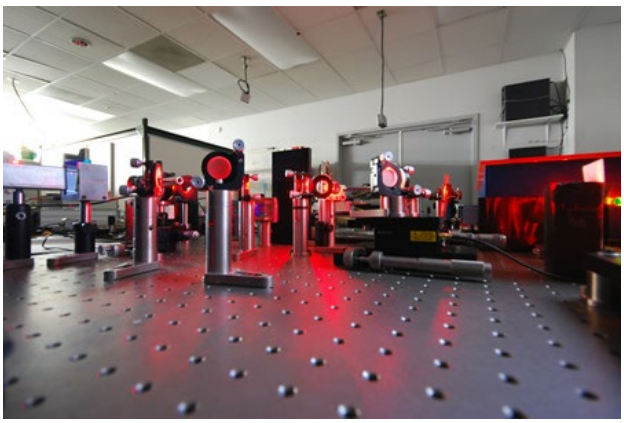


Figure 6: *UCF Nanoscience Technology Center Laser Setup*

Class 1 Lasers

- Class 1 lasers are considered to be incapable of producing damaging radiation levels and are exempt from most control measures or other forms of surveillance.

Class 1M Lasers

- Class 1M lasers are considered to be incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or a telescope (collimated beam).
- They are exempt from any control measures other than to prevent potentially hazardous optically aided viewing and are exempt from other forms of surveillance.

Class 2 Lasers

- Class 2 lasers emit radiation in the visible portion of the spectrum, and protection is normally afforded by the normal human aversion response (blink reflex) to bright radiant sources.

- They may be hazardous if viewed directly for extended periods of time.

Class 2M Lasers

- Class 2M lasers emit radiation in the visible portion of the spectrum, and protection is normally afforded by the normal human aversion response (blink reflex) to bright radiant sources.
- However, class 2M is potentially hazardous if viewed with certain optical aids.

Class 3R Lasers

- Class 3R lasers are those that normally would not produce injury if viewed only momentarily with the unaided eye.
- They may present a hazard if viewed using collecting optics, e.g., telescopes, microscopes, or binoculars.

Class 3B Lasers

- Class 3B lasers may cause severe eye injuries through direct or specular exposure, but is normally not a diffuse reflection or fire hazard.

Class 4 Lasers

- Class 4 lasers are a hazard to the eye from the direct beam and specular reflections and sometimes even from diffuse reflections.
- They can also start fires and can damage skin.
- Class 4 lasers may also produce laser generated air contaminants (LGAC) and hazardous plasma radiation.

VI. Laser Hazards

Laser Beam Hazards

Eye Injury

Light causes biological damage through both temperature effects due to absorbed energy and through photochemical reactions. The chief mode of damage depends on the wavelength of the light and the tissue being exposed. For control of hazards from lasers, the damage is believed to be due principally to temperature effects, with the critical organs being the eye and the skin.

The primary rule of laser safety is to NEVER UNDER ANY CIRCUMSTANCES LOOK INTO ANY LASER BEAM! If you can prevent the laser beam and beam reflections from entering the eye, you can prevent a painful and possible blinding injury. The components of the eye that are most susceptible to laser damage are the cornea, retina, and lens, depending on the wavelength of the light and the energy absorption characteristics of the ocular tissues. The potential location of injury in the eye is directly related to the wavelength of the laser radiation. For laser radiation entering the eye:

Near Ultraviolet Wavelengths (UVA) 315 - 400 nm

- Most of the radiation is absorbed in the lens of the eye.
- The effects are delayed and do not occur for many years (e.g.; cataracts).
  Far Ultraviolet (UVB) 280 - 315 nm and (UVC) 100 - 280 nm
- Most of the radiation is absorbed in the cornea.
- Keratocojunctivitis (snow blindness/welder's flash) will result if sufficiently high doses are absorbed.

Visible (400 -760 nm) and Near Infrared (760 - 1400 nm)

- Most of the radiation is transmitted to the retina.
- Overexposure may cause flash blindness or retinal burns and lesions.

Far Infrared (1400 nm - 1 mm)

- Most of the radiation is transmitted to the cornea.
- Overexposure to these wavelengths will cause corneal burns.

Skin Injury

The skin is the largest organ of the body and is at the greatest risk for coming in contact with the laser beam. The most likely skin surfaces to be exposed to the beam are the hands, head, or arms. Laser effects on tissue depend on the power density of the incident beam, absorption of tissues at the incident wavelength, the time the beam is held on tissue, and the effects of blood circulation and heat conduction in the affected area.

Immediate Effects

The immediate effect of exposure to laser light above the biological damage threshold is normally burning of the tissue. Injury to the skin can result either from thermal injury following temperature elevation in skin tissues or from a photochemical effect (e.g., "sunburn").

Delayed Effects

The possibility of adverse effects from chronic laser irradiation to the skin has been suggested, although it is normally discounted. Only optical radiation in the ultraviolet region of the spectrum has been shown to cause long-term, delayed effects such as accelerated skin aging and skin cancer. At present, laser safety standards for exposure of the skin attempt to take these adverse effects into account.

Non-Beam Hazards

As shown previously, an exposure to laser light can be hazardous to both the eye and skin. There are other hazards related to the operation of a laser besides exposure to the beam or its reflection. Many of these non-beam related hazards can be far more dangerous than the beam itself.

Chemical Hazards

Compressed Gases

Many lasers that are used that incorporate hazardous gases such as chlorine, fluorine, hydrogen chloride, and hydrogen fluoride. Referring again to ANSI Z136.1, there are typical safety problems that arise in the use of compressed gasses. These include**s**:

- Working with free-standing cylinders that are not isolated from personnel.
- Inability to protect open cylinders (regulator disconnected) from atmosphere and contaminants.
- No remote shutoff valve or provisions for purging gas before disconnect or reconnect.
- Labeled hazardous gas cylinders not maintained in appropriate exhausted enclosures.
- Gases of different categories (toxics, corrosives, flammable, oxidizers, inert, high pressure, and cryogenics) not stored separately in accordance with OSHA and Compressed Gas Association requirements.

Laser Dyes and Solvents

Dyes are used in some lasers as a lasing medium. These dyes are complex organic compounds that are mixed in solution with certain solvents. Some dyes are highly toxic or carcinogenic, and great care must be taken when handling them, preparing solutions, and operating lasers that contain these dyes. A Safety Data Sheet must be made available to anyone working with these dyes.

Fumes, Vapors, and Laser Generated Air Contaminants from Beam-target Interaction

Air contaminants may be generated when certain class 3B and class 4 laser beams interact with matter. When the target irradiance reaches a given threshold (app. 10^7 W/cm^2), target materials, such as plastics, composites, metals, and tissues, may vaporize, creating hazardous fumes or vapors that may need to be captured or exhausted. Exposure to these contaminants must be controlled to reduce exposure below acceptable OSHA or national permissible exposure limits. The SDS may be consulted for this information. Exhaust ventilation, including use of fume hoods, should be used to control airborne contaminants.

Electrical Hazards

With the use of large power supplies and repetitively pulsed lasers, there is a great potential for electric shock. Shocks usually happen when a person is working on equipment that is not properly grounded or has a large capacitor bank that was not discharged. Most injuries to personnel involving lasers are of this type. For this reason, the "buddy" system should always be observed when performing maintenance on high voltage equipment. According to the ANSI Z136.1, the following potential problems have frequently been identified during laser facility audits:

- Uncovered electrical terminals.
- Improperly insulated electrical terminals.
- Hidden "power up" warning lights.
- Lack of training in current cardiopulmonary resuscitation practices or lack of refresher training.
- "Buddy system" not being practiced during maintenance and service.

- Non-earth-grounded or improperly grounded laser equipment.
- Non-adherence to the OSHA lock-out standard (29CFR1910.147).
- Excessive wires and cables on floor that create fall or slip hazards

Ergonomics and Human Factors

Ergonomic problems can arise from a laser operation that causes awkward arm and wrist positions. If these positions occur for prolonged periods of time, medical problems such as repetitive strain injuries may arise. Back injuries can occur from stretching or strains caused by poorly designed enclosures that are repeatedly taken on and off.

Explosion Hazards

With the use of high-pressure arc lamps, filament lamps, and capacitor banks in laser equipment, there is a potential for explosion hazards. These items should be enclosed in housings that can withstand the high pressure resulting from exploding components.

Fire Hazards

There is a great potential for a fire hazard to exist with the use of Class IV lasers. Fires can occur when a Class 4 laser is enclosed in a material that is exposed to irradiances greater than 10 W/cm^2 or beam powers exceeding 0.5 W. Fire resistant materials should be used in this situation. Barriers such as black photographic cloth are used in a wide variety of applications for the purpose of containing the beam. These materials should not be used as the primary barrier for a high-powered Class 4 system. Beams of sufficient energy will burn this material quickly, causing smoke, fire, and breach of the barrier. The use of beam blocks and beam stops is highly encouraged in this situation.

Noise

Some lasers, such as the Excimer, create an intensity of noise that may require controls to be instituted. Noise can exceed safe limits because of high-voltage capacitor discharges and in laser peening operations. In these cases, hearing equipment may be required. A noise-filled environment can mask the sound of alarms; in such cases visual alarm systems are advisable. The UCF Industrial Hygienist, should be consulted if there are concerns about noise at 407-823-6077.

Radio-Frequency (RF) Radiation Hazards

Some lasers contain RF excited components, such as plasma tubes and Q-switches. Unshielded and loose-fitting components may generate RF fields. RF leakage surveys should be conducted each time RF cables are reconnected.

X-Ray Radiation Hazards

X-rays may be generated by electronic components of the laser system (e.g., high-voltage vacuum tubes and from laser-metal induced plasmas). Any power supplies that require more than 15 kV may produce enough x-rays to be a health concern.

Plasma radiation

Materials can be made incandescent when exposed to laser radiations. These incandescent spots are very bright and cause serious photochemical injuries to the eyes. The laser protective

eyewear may not protect against such exposures. View such spots through suitable filters; use video cameras, etc., as may be appropriate.

VII. Laser Protective Equipment

Eye Protection

Figure 7: *Legible ODs and wavelengths from the manufacturer must be visible and legible on the laser safety eyewear being used.*

Suitable eye protection while using lasers is not for just protecting against eye injury and vision loss, but also maintaining appropriate vision to perform tasks and carry out research. Most laser incidents that result in eye injury are a result of not utilizing eyewear, eyewear failure, improper eyewear, or an improper fit. If there is a possibility of viewing the beam at levels exceeding the MPE (Maximum Permissible Exposure) level, appropriate eye protection must be provided for all personnel within the laser controlled area. The eye protection must have an appropriate optical density at the wavelengths of the beams to be encountered, the beam irradiance, and the expected exposure conditions. At the same time, the need for laser eye protection must be balanced by the need for adequate visible light transmission. To select the proper laser eye protection, one should contact the LSO.

Eyewear can either be made of glass or plastic. Glass is scratch resistant, has a higher optical quality, good visual transmittance, and stability against bleaching. Plastic eyewear is low weight, break resistant, and much less expensive.

Taking care of your eyewear is just as important as wearing it. Eyewear should be stored in proper compartments to keep away from contaminants. Eyewear should be cleaned following the manufacturer's directions. It should be inspected periodically to ensure that it is in good condition. If eyewear becomes scratched, cracked, or breaks, it must not be worn; the effectiveness at protecting vision can become compromised if the eyewear is damaged. Eyewear must be labeled with the wavelength and OD; if label becomes unreadable, contact the LSO for possible re-labeling.

Skin Protection

Skin protection can best be achieved through engineering controls. If there is a potential for skin damaging exposures, skin covers and/or "sun screen" creams are recommended. Minimize exposure to UV radiation by using beam shields and clothing (opaque gloves, tightly woven fabrics, laboratory jacket or coat) which attenuate the radiation to levels below the MPE level for specific UV wavelengths. Consider flame retardant materials for Class 4 lasers. In addition, special attention must be given to the possibility of producing undesirable reactions in the presence of UV radiation (formation of skin sensitizing agents, ozone, etc.).

Window Protection

Exterior or interior windows that are located within the Nominal Hazard Zone (NHZ) of a Class 3B or Class 4 laser within a laser system must be provided with appropriate absorbing filter, scattering filter, blocking barrier, or screen to reduce any transmitted laser radiation to levels below the applicable MPE level. Important factors for selection include: ability to withstand direct and diffusely scattered beams, flammability, and decomposition products of the window material.

Barriers and Curtains

A blocking barrier, screen or curtain which can block or filter the laser beam at the entryway should be used inside the controlled area to prevent Class 3B or Class 4 laser light from exiting the area at levels above the applicable MPE level. Important factors for selection include: ability to withstand direct and diffusely scattered beams, flammability, and decomposition products of the protective barrier or curtain.

VIII. Control of Classified Lasers and Area Safety

A. Control of Classified Lasers**

Listed below are the controls required for the various laser classifications. Controls are listed by engineering and administrative controls.

Class 1 and Class 1M

Engineering Controls	Administrative Controls
• Protective housing shall be provided. • If the MPE level is exceeded, a temporary laser controlled area shall be devised. • If the laser system is an embedded Class 3B or 4 laser, interlocks shall be provided on removable parts of the housing. • If the laser system is an enclosed Class 3B or 4 laser, interlocks shall be provided on any removable parts of the housing, or the laser shall have a service access panel that is either interlocked or requires a tool for removal.	• If the laser system is an embedded Class 3B or 4 laser and the MPE level is exceeded, service personnel shall comply with the control measures appropriate for the class of the embedded laser.

Class 2

Engineering Controls	Administrative Controls
• Protective housing shall be provided. • Warning labels shall be conspicuous. • If the laser system has an embedded Class 3B or 4 laser, interlocks shall be provided on removable parts of the housing. • If the laser system is an enclosed Class 3B or 4 laser, interlocks shall be provided on any removable parts of the housing, or the laser shall have a service access panel that is either interlocked or requires a tool for removal. • If the MPE level is exceeded, a temporary laser controlled area shall be devised.	• If the laser system has an embedded Class 3B or 4 laser and the MPE level is exceeded, service personnel shall comply with the control measures appropriate for the class of the embedded laser.

Class 2M

Engineering Controls	Administrative Controls
• Protective housing shall be provided. • Warning labels shall be conspicuous. • The area should be posted with the appropriate warning sign(s). • If the MPE level is exceeded, viewing portals and/or display screens shall be designed such that MPE level is not exceeded. • If the laser system is an enclosed Class 3B or 4 laser, interlocks shall be provided on any removable parts of the housing, or the laser shall have a service access panel that is either interlocked or requires a tool for removal. • If the MPE level is exceeded, a temporary laser controlled area shall be devised.	• If laser system has an embedded Class 3B or 4 laser and the MPE level is exceeded, service personnel shall comply with the control measures appropriate for the class of the embedded laser. • Alignment procedures shall ensure that the MPE level is not exceeded.

Class 3R

Engineering Controls	Administrative Controls
• Protective housing shall be provided. • Warning labels shall be conspicuous.	• Education and training shall be provided for users.

• A permanent beam stop or attenuator should be provided. • The area should be posted with the appropriate warning sign(s). • If the laser has a service access panel, it shall be interlocked or require a tool for removal. • If the MPE level is exceeded, a temporary laser controlled area shall be devised. • If the MPE level is exceeded, viewing portals and/or display screens shall be designed such that MPE level is not exceeded.	• Alignment procedures shall ensure that the MPE level is not exceeded. • If the laser system has an embedded Class 3B or 4 laser and the MPE level is exceeded, service personnel shall comply with the control measures appropriate for the class of the embedded laser.

Class 3B

Engineering Controls
• Protective housing shall be provided. • Interlocks shall be provided on removable parts of the housing. • If the entire beam is not enclosed, a Nominal Hazard Zone (NHZ) determination shall be made by the LSO; a controlled area shall be established and control measures shall be implemented. • If there exists a limited open beam path, a NHZ determination shall be made by the LSO. • The appropriate warning signs shall be posted. • All labs must block line of sight of lasers at entryway by using a barrier at the door or table blocks. • The controlled area shall be operated by trained and authorized personnel. • A key-controlled master switch should be provided. • A permanently attached beam stop or attenuator should be provided. • An alarm, warning light, or verbal countdown should be used during use or start-up of the laser. • If the MPE level is exceeded: o Viewing portals and/or display screens shall be designed such that the MPE level is not exceeded. o Collecting optics shall be designed such that the MPE level is not exceeded. • The controlled area should: o Be supervised by an individual with knowledge of laser safety and have limited access to spectators. o Have beam stops to terminate potentially dangerous laser beams as well as be designed to reduce diffuse and specular reflections. o Have eye protection for personnel. o Be free of any laser beams at sitting or standing eye level.

- Have restrictions on windows and doorways to reduce exposure to levels below the MPE level.
- Require storage or disabling of the laser when it is not being used.

Administrative Controls
• Education and training shall be provided for laser users. • Only authorized personnel shall service the laser. • Alignment procedures shall ensure that the MPE level to the eye is not exceeded. • Control procedures shall be followed by service personnel. • The LSO shall implement controls necessary to reduce exposure if the LSO considers exposures to be excessive. • Approved, written standard operating, maintenance, and service procedures shall be developed unless specifically exempted by the LSO.* • Appropriate eye protection should be required. • Unauthorized persons should not be permitted within the controlled area. • A lab laser safety supervisor should be designated for each individual lab.

** Class 3B HeNe lasers with power of 15 milliwatts or less and those over ten years old are exempted by policy from SOP and registration requirements.*

Class 4

Engineering Controls

• Protective housing shall be provided.
• Interlocks shall be provided on removable parts of the housing.
• Service access panels shall be interlocked or require a tool for removal.
• A key-controlled master switch shall be provided.
• If laser is software controlled, computer must be password protected
• The appropriate warning sign(s) shall be posted.
• All labs must block line of sight of lasers at entryway by using a barrier at the door or table blocks.
• When the entire beam is not enclosed, a NHZ shall be established.
• When there exists a partially limited beam path, a NHZ shall be established.
• Permanent beam stop or attenuator shall be provided.
• An alarm, warning light, or verbal countdown shall be used during use or start-up of the laser.
• The controlled area shall:
  ○ Be restricted to authorized personnel only.
  ○ Be designed to allow for rapid emergency egress.

- Be equipped with a device that allows for deactivation of the laser or reduction of output to below the MPE level.
- Be designed to fulfill Class 3B controlled area requirements.
- Be designed with entry safety controls.

- The laser should be monitored and fired from a remote location.
- If the MPE level is exceeded:
  - Viewing portals and/or display screens shall be designed so as not to exceed the MPE level.
  - Collecting optics shall be designed so as not to exceed the MPE level.

Administrative Controls
• Approved, written standard operating, maintenance, and service procedures shall be required. • Education and training shall be provided for users. • Only authorized personnel shall operate, maintain or service the laser. • Alignment procedures shall ensure that the MPE level for the eye is not exceeded. • Eye protection must be required. • Spectators shall be allowed in the controlled area only with approval and after a safety briefing, and proper eyewear and personal protective equipment available. • Service personnel shall comply with control procedures. • The LSO shall take measures to reduce output if the output is considered to be excessive. • A lab laser safety supervisor should be designated for each individual lab.

***Adopted from ANSI Z136.1-2014 and ANSI Z136.8-2012*

B. Labeling Requirements of Lasers

All lasers must be labeled with the proper information that includes:

- Certification label
- Identification label
- Name and address of manufacturer
- Place, month, and year of manufacture
- Hazard classification
- Radiation output info and warning logotype
- Aperture label

All Class 3B and 4 lasers must also have a UCF inventory tag *(See Figure 10: Laser Safety Inventory Tag, LS-2T)*, distributed by EHS upon registration of the laser with the Florida Department of Health.

C. Proper Warning Identification for Laser Controlled Areas

The term "proper warning indication" generally means that an illuminated warning sign is outside of the area. Preferably the light should be flashing and lit only when the laser is on. (When

a Class 3B or 4 Laser is left on and the personnel leave the room, the door shall always be locked.) Lights alone do not suffice as adequate warning, unless the light is clearly posted as to its meaning. A well-designed warning light should have redundancy, e.g., two lights, a "safe" light when the laser is off, or two lamps wired in parallel, in the "laser on" signal.

Newly constructed laboratories should have a well-designed provision in installing interlocks. PI's, design and planning Engineers and should work with EHS to review and determine installation of proper access controls.

ANSI Z136.1 *Safe Use of Lasers* indicates that laser area warning signs should be posted around Class 3R laser areas and is required to be posted around all Class 3B and 4 laser areas. Additionally, "NOTICE" signs are required for Class 3B and Class 4 lasers during maintenance, servicing, and similar situations *(See Figure 8: Sample ANSI Z535.2 Compliant Laser Signs)*.

Figure 8a: Sample ANSI Z535.2 Compliant Caution Sign for Class 2, Class 2M and Class 3R Lasers (*from ANSI Z136.1-2014)*

Figure 8b: Sample ANSI Z535.2 Compliant Warning Sign for Class 3B, Class 4 Lasers (*from ANSI Z136.1-2014)*

Figure 8c: Sample ANSI Z535.2 Compliant Class 4 Laser Controlled Area Danger Sign Format (*from ANSI Z136.1-2014)*

D. Standard Operating Procedures

A **Standard Operating Procedure (SOP)** is a formal written description of the safety and administrative procedures to be followed in performing a specific task. As part of administrative and procedural controls, standard operating procedures detailing standard operations, maintenance, and service must be written and approved by the Laser Safety Officer for Class 3B and 4 lasers or laser systems (Note: Continuous wave visible lasers at or below 15 mW are exempt from this requirement). These approved SOPs must be kept in the laser safety manual for reference. *(See Appendix C: Standard Operating Procedures Template (SOP)*.

Standard Operating Procedure (SOP) Development

Use the EHS SOP website to find SOPs relevant to your lab that you can modify for your specific purposes. Your lab must have copies of the relevant SOPs and documented training for lab personnel that perform that task.

How do I prioritize which SOPs to develop?

SOPs are required for hazardous operations that include use of hazardous chemicals and/or equipment that could cause harm to lab workers.

A. Lasers can produce Laser Generated Air Contaminants (LGAC) and also present chemical hazards with some toxic chemicals that are used (dyes, solvents, and hazardous gases). Use your knowledge about your lab's chemicals.

B. The UCF Chemical Inventory System has a built-in "Particularly Hazardous Chemical" report which lists hazardous chemicals in your lab's chemical inventory that are highly toxic, carcinogenic, or reproductive hazards. This report can be used to help prioritize your SOP development.

    a. Each lab has a chemical inventory contact. Only s/he/they has/have access to the Chemical Inventory program. Others have read only access but should still be able to view info

b. Once logged into the Chemical Inventory program and "in the room view", go the "Special" menu and select "Show Related Items." Then select "Particularly Hazardous Chemical" from the "Special" menu.

C. Consider not only operational practices, but also alignment, maintenance, and service of lasers.

D. Consider fire hazards and noise if these risks exist or are a possibility.

IX. Training and Qualifications of Employees

A. Training and Requirements

All students and employees who will be accessing the laser labs/areas shall receive laser safety awareness training. All training should be conducted by a knowledgeable designated person, and should be presented in a manner that the employee can understand. Each employee must demonstrate an understanding of the training specified and the ability to use PPE properly, before being allowed to perform work.

Figure 9: *CREOL Laser User, University of Central Florida*

All users of Class 3B or Class 4 lasers must, in addition to the laser safety awareness training:

- Familiarize themselves with the UCF Laser Safety Program.
- Receive laboratory-specific safety training from their supervisor or Principal Investigator (PI) which includes, but is not limited to: a review of the laser equipment, review of administrative and engineering controls, alignment procedure, and standard operating procedures.
- Read and sign a copy of applicable standard operating procedures for that lab.
- Sign a UCF Laser Safety Written Certification Form (LS-3). *(See Appendix F – Written Certification Form (LS-3).*

B. Written Certification

The employer shall verify that each affected employee has received and understood the required training through a written certification that contains the name of each employee trained, the date(s) of training, and the subject of the certification *(See Appendix F: Written Certification Form, LS-3)*. This form should be kept in the laser safety manual notebook.

X. Laser Inventory and Approval

Figure 10: *Laser Safety Inventory Tag (LS – 2T) distributed by UCF EHS*

Applicable control measures must be set in order to evaluate the laser or laser system's capability of injuring personnel, environment in which the laser will be operated, and individuals that will be using or be exposed to the laser. One method to ensure adequate control measures is to conduct a laser safety inventory of the lasers present in the institution. Only those that are class 3B and 4 will be inventoried. A completed laser registration form *(See Appendix D: Laser Registration Form, LS-1)* is to be submitted by the PI or designated laser safety supervisor of the lab to EHS and an EHS representative will inventory the laser(s) requested to be used, complete the DH1605 Laser Registration Form for the Florida Department of Health, and provide the laboratory with a copy of the certified DH1605.

Lasers already in the UCF Laser Program and its current inventory will be "grandfathered" in and tags shall be distributed and placed by EHS. Laser inventory and inventory tags for each laboratory and department will be physically inspected annually and checked in the database.

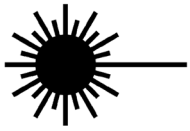
When a new laser is acquired, the laser must be registered with the Florida Department of Health within 30 days of the acquisition. Prior to operation, the Laser Use Checklist (LS-4) should be completed *(See Appendix G, Laser Use Checklist, LS-4)*, and a Laser Approval Form (LS-2) issued by EHS. Upon completing the checklist, the PI will ensure that all designated laser users have completed UCF EHS training, SOPs for the laser system have been submitted to EHS, and an initial inspection of the space has been completed. This also allows for compliance with the Florida Department of Health in not only proper documentation has been filed, but also all applicable standards for laser safety are in place.

XI. Medical Surveillance

Regular eye exams are not required at this time for personnel working with class 3B or 4 laser systems. In the case of a reported incident, an eye exam will be recommended. If risk assessment warrants it, medical surveillance may be required before, during, and after an assignment. The department that the Authorized User or laser worker is assigned to is responsible for the cost of the eye examination.

XII. Appendices

Appendix A – UCF Laser Safety Program



LASER SAFETY PROGRAM
UNIVERSITY OF CENTRAL FLORIDA
2023 Edition

Principal Investigator (PI)

Environmental, Health and Safety (EH&S) Representative (LSO)

Laser Acquisition

Submit Paperwork at the Time of Acquisition (Workday)/Loan (Huron)

Submit to EH&S the following:
- Laser Registration (LS-1)
- Standard Operating Procedure (SOP)
- Laser Used Checklist (LS-4)

Conduct Review, Inspection and Validation

Approves LS-1 and SOP

Issue Laser Approval Form

Tag Laser for Inventory tracking

Accomplish and submit to Florida Department of Health Form DH 1605

Designate Laser Safety Manager

PI/s and User/s Comply and Complete Training Requirements

Work with EH&S to determine safe conditions of operations including eye safety eyewear, etc.

Accomplish and submit to EH&S Written Certification Form

Follow Safe Operation Procedures

Emergency Procedures

If an injury has occurred as a result of an exposure, first provide first aid and seek medical attention at UCF Student Health Services or Centra Care Urgent Care on University Blvd. If an exposure has occurred or is suspected, then the Principal Investigator or Authorized User must contact UCF Environmental Health and Safety as soon as possible. This exposure must be reported to maintain compliance with worker's compensation guidelines. An incident investigation will be performed and a report presented to the PI or Authorized User with the findings and corrective actions.

Environmental Health and Safety staff are available to respond to an exposure before and after normal business hours (Monday through Friday 8 a.m. to 5 p.m.)

Phone Numbers

In the event of an emergency, first contact the UCF Police Department (911).

UCF Environmental Health and Safety contacts:

EH&S	(407) 823-6300
Laser Safety Officer	(407) 823-0476
UCF Industrial Hygienist	(407) 823-6077

Medical Treatment and Urgent Care

UCF Student Health Services Health Center, Room 101 4098 Libra Drive Orlando, FL 32816-3333 Phone: **(407) 823- 2701**	**OPERATING HOURS:** Mon-Fri: 8:30am - 6:00pm Saturdays: 10:00am-2:00pm *Holiday Hours may vary
Care Now – Urgent Care 7460 University Blvd, Ste. 110 Winter Park, FL 32792 Phone: (407) 410-8945	**OPERATING HOURS:** Mon - Fri: 8 AM – 8 PM Sat - Sun: 8 AM – 7 PM

Other Hospitals & Urgent Care Clinics

AdventHealth – East Orlando 7727 Lake Underhill Road 407-303-8110	AdventHealth Centra Care – University 11550 University Boulevard 407-384-0080
Winter Park Memorial Hospital 200 N. Lakemont Avenue 407-646-7000	AdventHealth Centra Care – Hunter's Creek 3293 Greenwald Way, N 407-847-2796
Paramount Urgent Care – Oviedo 1984 Alafaya Trail Oviedo, FL 32765 407-542-0346	AdventHealth Centra Care – Sand Lake 2301 Sand Lake Road 407-851-6478
GuideWell Emergency Doctors (Urgent care, also offering CT Scan and treatment of major medical conditions) 1706 N. Semoran Blvd. 321-804-9110	AdventHealth Centra Care – Oviedo 8010 Red Bug Lake Road 407-200-2512
GuideWell Emergency Doctors (Urgent care, also offering CT Scan and treatment of major medical conditions) 113 N. Orlando Ave., Winter Park 407-801-8400	AdventHealth Centra Care – Waterford Lakes 250 N. Alafaya Trail, #135 407-381-4810
Night Lite Pediatrics – Oviedo (Sees patients who are under the age of 22) 1500 Alafaya Trail Oviedo FL 32765 407-385-1790	AdventHealth Centra Care – Downtown 630 Bumby Avenue 407-894-3521
Night Lite Pediatrics – East Orlando (Sees patients who are under the age of 22) 11325 Lake Underhill Rd. Orlando FL 32825 407-398-6702	Oviedo Medical Center 8300 Red Bug Lake Road, Oviedo 407-890-CARE Text "ER" to 2300 for average ER wait time

Appendix C- Standard Operating Procedure (SOP) Template

UCF	Department of _____ Standard Operating Procedure for LASERS		
Laser Name/Class and Wavelength		**Laser Model and Serial Number**	
Laser Manager		**Building/Lab No.**	
Revision Number		**Date:**	
Revision made by		**Approved by PI:**	

1. **Circumstances of Use:**

This Standard Operating Procedure (SOP) outlines requirements to be considered by an authorized user of the XXXXnm laser as well as describes the normal operation of the laser and any hazards that may be encountered during normal operation. Finally, the SOP explains how to minimize any hazards and how to respond in an emergency. This document is to be reviewed one year from the date of approval or as conditions warrant, whichever is the shorter time period.

2. **Potential Hazards:**

A. Laser Hazards: The XXXXnm laser is a Class X laser. Severe eye damage (including blindness) and skin damage can result from direct beam and specular reflections. Eye damage can also result from diffuse reflections.
B. Electrical Hazards: electrical shock or electrocution could result from direct contact with high voltage. Be careful to make sure no liquids are on your gloves or hands when plugging laser power cords into power supply.
C. Chemical: Keep flammable solvents out of beam path.

3. **Work Practice Controls:**

A. Lasers

1) Only authorized personnel will operate lasers.
2) The laboratory doors will be closed, and the warning light will be turned on when the laser is operating.
3) During alignments, the laboratory doors will be closed, and the warning light will be turned on.
4) Unauthorized personnel will be only allowed entry to the laboratory during laser operation with the supervision of an authorized user under the terms specified by the PI.
5) Laser protective eyewear of OD X+ for working with the XXXXnm laser is available on the wall-mounted rack inside the lab, immediately to the right after entering.
6) Laser protective eyewear must always be worn when the laser is in operation.
7) No filters or other optics will provide suitable protection; use only laser safety protective eyewear with optical density necessary for the output power in use. *PLEASE NOTE:*

Laser protective eyewear is specific for the wavelength and power output and proper selection is important.

8) Specular and diffuse reflections will be controlled using apertures, beam housings, enclosures, and optics. All control methods must be in place during normal operation.
9) Laser alignment must be performed only by following the steps outlined in the alignment procedures in Section 5B.
10) Perform physical surveys to determine if there are stray beams (specular or diffuse emanating from each laser and its optics, and then document the beam surveys noting the location of stray beams and the measures taken to control them.
11) Methods of documentation of survey may be recorded.
12) If the beam path must be changed significantly by relocating the laser or optics, all users must be notified of the change.
13) The same precautions that are taken for safe operation of the laser must also be followed when adjusting any of the optics in use with the apparatus.
14) When a new principal researcher/experimenter takes over the use of the laser system, the new user must conduct a survey for unwanted stray or diffuse beams.

B. Electrical

1) Enclosures for protection against the high voltages of the laser power supply or laser head may only be removed after the power supply has been unplugged from the outlets and after following the safety procedures outlined in the safety and operations manual provided by the manufacturer.
2) Only qualified personnel may perform all internal maintenance to the laser and more than one user must be present when performing said maintenance.
3) Every portion of the electrical system, including the printed circuit cards, should be assumed to be at a dangerous voltage level.

C. Chemical

1) Always check that any flammable solvent placed under the laser beam does not ignite or combust by referencing the flash point of the chemical and the temperature increase of the chemical under laser exposure.

4. Personal protective equipment (PPE):

A. OD X+ laser protective eyewear specific to the wavelength and power of the laser.
B. Ultraviolet opaque clothing when working around high intensity UV lasers.
C. Long pants and closed toe shoes.

5. Experimental Procedure:

A. Normal Operation

1) Inspect all electrical and water connections for damage and connectivity.
2) Remove any jewelry or clothing that may reflect beams.
3) Obtain appropriate eyewear. Be certain it is of appropriate OD for the wavelength(s) in use.
4) Turn on the outside warning light
5) Close all doors and laser curtains/barriers.
6) Remove cover from optical setup.
7) Inspect optical setup for recent changes and/or foreign objects.
8) Verify that all engineering controls are in place and ensure that the laser path will be blocked.

9) Verify that all personnel in the lab are wearing the appropriate eyewear.
10) Issue verbal warning prior to starting laser.
11) Remove cap from laser.
12) Turn on laser power supply.
13) Insert key into laser controller.
14) Turn laser system on.

B. System Alignment

1) Inspect all electrical and water connections for damage and connectivity.
2) Use low-powered alignment laser, when possible.
3) Complete the Normal Operations checklist in Section 5A.
    a. The checklist serves to confirm that all basic systems are operating within expected parameters and that basic safety mechanisms are in place.
4) If a low-powered alignment laser is not available, adjust the beam power to the lowest possible power for alignment.
5) Adjust the laser to ensure that the beam is centered on the optic.
6) Using a viewing card or an electronic viewer, check for stray beams (including those behind the mirror), block these stray beams.
7) Continue these steps until all optics are properly aligned.
8) Check that all mounts are tightly in place and will not inadvertently shift, causing changes in alignment.
9) Only after completing these procedures should the laser be increased to desired power and repetition rate.
10) If more than one person is present, announce increase in power so that all people present are aware of the change.

Note:

a. Allow only trained personnel to be present during alignment. Minimize the number of personnel present during the alignment.
b. All people present must wear appropriate eyewear.
c. If possible, avoid using beam paths that are at sitting or standing eye level.
d. Where feasible, use low power (class 2 or 3A) visible lasers to simulate the path of high power or invisible lasers.
e. Where feasible, terminate laser beams and specular reflections on diffuse reflecting beam blocks.
f. Locate any specular reflections of the beam and block them as close to the source as possible.
g. Whenever possible, reduce all high-power laser beams to the minimum possible power.
h. Use beam shutters to block high power beams any time they are not actually needed.

C. System Shutdown

1) Shut down laser system.
2) Remove key from laser controller.
3) Turn off laser power supply.
4) Put cap on laser.
5) Place cover over optical setup.
6) Return eyewear to the wall-mounted rack by the lab entrance.

7) Turn off the outside warning light.

D. Emergency Procedures

1) Shut down the laser system.
2) Provide for the safety of personnel (first aid, evacuation, etc.). Seek medical assistance:
3) During normal business hours:
4) If you are an employee of UCF, contact UCF Health: 407-266-3627 and follow their instructions.
5) If you are a student, refer to Student Health Services: 407-823-2701 and follow their instructions.
6) After normal business hours: Contact **Care Now – Urgent Care,** 7460 University Blvd, Ste. 110 Winter Park, FL 3279, Phone: (407) 410-8945.
7) Inform your Principal Investigator of the accident as soon as possible. An Incident Report must be filed within one business day after the accident. Information on completing an Incident Report can be obtained at: https://ehs.ucf.edu/accident-investigation
8) Inform the UCF Laser Safety Officer of the accident as soon as possible: 407-823-0476 or Mario.DeVera@ucf.edu.

6. Waste Disposal:

Waste Policies & Programs

7. Exposures/Unintended contact:

Contact Environmental Health and Safety at (407) 823-6300 for medical advice on occupational chemical exposures. For an actual chemical exposure, complete the work-related injury or illness report found at: EH&S, Workplace Safety, Accident Investigation Form.

8. Spill Procedure:

Follow procedures outlined in Laboratory Safety Manual.

9. Training of personnel:

A. Authorized Personnel: The XXXXnm laser may be operated only by authorized personnel who are fully cognizant of all safety issues involved in the operation of such a device. These personnel are to ensure that the laser is only operated in the manner laid out in this document.

B. To become an authorized user, one must:

1) Successfully complete EHS 309 online laser safety training.
2) Unless required, obtain a baseline ophthalmologic examination (considered optional by ANSI Z136.1)
3) Read and fully understand the SOP
4) Receive training on the XXXXnm laser by an authorized user.
5) Sign and date the authorized user sheet to affirm that the above steps have been completed.

C. **Unauthorized personnel:** No unauthorized personnel may enter during laser operation unless accompanied by an authorized user. All visitors must be briefed on proper safety protocol and must wear appropriate laser protective eyewear located on the premises.

10. Documentation of Training *(Signature of all users is required)*

Training records must be in lab for SOP. Training record must state the SOP that the person was trained on and must contain the phrase "I have read and understand the content of this SOP", followed by the person's name, signature, and date of training.			
"I have read and understand the content of this SOP."			
Name	*Signature*	*Date of Laser Safety Orientation Training*	*Date of Lab Specific Laser SOP Training*

Appendix D- Laser Registration Form (LS-1)

UCF | Environmental Health and Safety

Laser Registration Form (LS-1)

All Class 3B and 4 lasers must be registered with the Florida Department of Health Bureau of Radiation Control within 30 days of acquiring them. By filling out this form, UCF EHS can assist you with registration of your laser and documentation to the FDOH BRC. Please contact the Laser Safety Officer at 407-823-0476 for any questions related to this form.

Principal Investigator Information:

Name: _____ Primary Department: _____

Affiliated Department: _____ Phone: _____ Lab Phone: _____

After Hour Phone: _____ UCF Email: _____

Lasers Information:

Building: _____ Room: _____

Laser Manufacturer: _____

Model Number: _____

Serial Number: _____

Laser Type (ND:YAG, etc.): _____

Classification (3B or 4): _____

Operational Wavelengths (nm): _____

Beam Diameter (mm): _____

Beam Divergence (mrad): _____

Average Power (W): _____ Max Power (W): _____ ☐ Continuous Wave

Joules/Pulse: _____ Pulse Width (sec): _____ ☐ Pulsed

Repetition Rate (Hz): _____ ☐ Q-Switched

Briefly explain the purpose and use of this laser in your research:

Protective Eyewear

Is protective eyewear present for all lab workers and visitor? ☐ Yes ☐ No
Link to online calculator for determining laser hazards including OD levels: _____ Easy Haz Website
Calculated Ocular MPE in Watts/cm2: _____ Easy Haz Website
Calculated Optical Density (OD) for protective eye-wear and laser danger sign: _____ Easy Haz Website
Calculated diffuse Nominal Hazard Zone (NHZ) in meters: _____ Easy Haz Website
Calculated intrabeam Nominal Optical Hazard Distance (NOHD) in meters: _____ Easy Haz Website

Standard Operating Procedures

Are standard operating procedures for the device(s) available? ☐ Yes or ☐ No

Authorized Laser Users Information

Name	Laser Safety Training Date	SOP read and signed	Name	Laser Safety Training Date	SOP read and signed

I certify that the information provided above is true and correct.

Principal Investigator: _____ Date: _____
EHS Radiation Safety: _____ Date: _____

Appendix E – Laser Approval Form (LS-2)

UCF | Environmental Health and Safety

Laser Approval Form
Approval Number: _____
Expiration Date: _____

Laser Safety

Principal Investigator/Laser User: _____ Department: _____
Phone: _____Email: _____Laser Laboratory or Room Location: _____
PI Training Date: _____

Laser in Inventory

Inventory #	Manufacturer	Model	Serial Number	Type (media)	Class	Wavelength	Output	Min OD

Protective Eyewear

Is protective eyewear present for all lab workers and visitors? ☐ Yes or ☐ No

Standard Operating Procedures

Are Standard Operating Procedures for the device(s) available? ☐ Yes or ☐ No

Authorized Personnel

Name	Laser Safety Training Date	SOP read and signed	Name	Laser Safety Training Date	SOP read and signed

I certify that the information provided above is true and correct.

Principal Investigator: _____ Date: _____
EHS Radiation Safety: _____ Date: _____

Appendix F – Written Certification Form (LS-3)

UCF | Environmental Health and Safety

Written Certification Form

I understand the risks and hazards involved in working with lasers, both beam and non-beam hazards. I have received proper training and instruction regarding the safe use of lasers from my institution, department, and Principal Investigator.

I certify that the information provided above is true and correct.

Principal Investigator: _____ Date: _____

EHS Radiation Safety: _____ Date: _____

Appendix G – Laser Use Checklist (LS-4)

Laser UCF | **Environmental Health and Safety**

Laser Use Checklist for New and Laser Setups

- ☐ Fill out the UCF Laser Safety – Laser Registration (LS-1) and return to EH&S
- ☐ Standard Operating Procedure have been submitted to EHS for Approval
- ☐ DH 1605, Florida Department of Health Laser Registration for is complete
- ☐ All lab members have completed UCF Laboratory Safety Training Online and Practical Sessions
- ☐ All laser users have received departmental laser safety training and have completed UCF EHS online laser safety training
- ☐ An initial start-up and inspection for your lab space has been completed by EHS

Florida Department of Health
Bureau of Radiation Control

LASER DEVICE REGISTRATION FORM

(PLEASE SUBMIT A SEPARATE FORM FOR EACH SEPARATE LOCATION)

4052 Bald Cypress Way, Bin C21
Tallahassee, FL 32399-1741
(850) 245-4266

NAME OF REGISTRANT: _____PHONE: (_____)_____-_____EXT. _____
STREET:_____CITY_____STATE_____ZIP_____COUNTY_____
ADDRESS OF LASER DEVICES (IF DIFFERENT FROM ABOVE) _____
STREET:_____CITY_____STATE_____ZIP_____COUNTY_____
NAME OF LASER SAFETY OFFICER: _____PHONE: (_____)_____-_____EXT. _____
STREET:_____CITY_____STATE_____ZIP_____COUNTY_____

ARE THESE LASERS PART OF A FIXED FACILITY OR ARE THESE MOBILE LASERS? FIXED FACILITY___ MOBILE LASERS ___

DESCRIPTION OF LASER DEVICES AT THIS LOCATION

MEDIUM (Argon, CO_2, Nd:YAG, etc.)	**CLASS** (IIIB or IV)	**TYPE** (CW or Pulsed)	**WAVE LENGTHs** (nm)	**MAXIMUM OUTPUT** (Watts or Joules)	**MANUFACTURER**	**MODEL**	**SERIAL**	**USE** (Medical, Construction, Industrial, Research, Entertainment, or Other)

FOR OFFICE USE ONLY

SIGNATURE OF REGISTRANT:_____ DATE: _____ REGISTRATION #:_____

NAME & TITLE: _____ EVALUATOR: _____

DH Form 1605, 6/06

Appendix I – Laser Inspection Checklist

P.I. Name:		Office Telephone:	
Department:		Contact Telephone:	
Survey Date:		Reviewed Date:	
Survey By:		Reviewed By:	

Inspection Location(s):

Building Name	Building Code	Lab/Room #

		Unsatisfactory	*Satisfactory*	*Needs Improvement*	*Information*	*Recommendation*
No Deficiencies Found	(NOV)	☐	☐	☐	☐	☐
Administrative and Procedural Controls						
Written Standard Operating Procedure available and complete	(L03)	☐	☐	☐	☐	☐
All authorized users have received laser safety orientation training, SOP-specfic training, and have signed the Authorized Personnel list on the SOP.	(L04)	☐	☐	☐	☐	☐
Class 3b and 4 laser inventory in lab matches Laser Device Registration Form	(L11)	☐	☐	☐	☐	☐
Beam Controls						
View of optics from entryway blocked.	(L05)	☐	☐	☐	☐	☐
Beam controls are adequate.	(L06)	☐	☐	☐	☐	☐
Laser and beam enclosure warning labels are adequate.	(L07)	☐	☐	☐	☐	☐
Entryway Controls						
Approved laser area warning signs present at all entryways	(L01)	☐	☐	☐	☐	☐
Class 4 laser lab entryways equipped with interlock or warning light.	(L02)	☐	☐	☐	☐	☐
Laser Safety Eyewear						
Appropriate eyewear available for all laser hazards present.	(L08)	☐	☐	☐	☐	☐
All eyewear labeled and in good condition.	(L09)	☐	☐	☐	☐	☐
Laser safety eyewear available at Class 4 entryways.	(L10)	☐	☐	☐	☐	☐

Additional Comments:

UCF Report of Accident / Near Miss Procedures

Instructions: This form shall be used to report ***all*** accidents or near miss events that occur at UCF. This helps us identify and correct hazards before they cause additional injuries to personnel or damage to property. This form shall be completed by employees / supervisors ***by the end of the shift in which the accident took place***. In the event of **multiple or serious injuries or death EHS must be notified immediately**.
Note: ***If more than one (1) employee is injured, you must fill out a separate Accident / Near Miss form for each employee.***

Terms: ***Accident*** is an unwanted outcome of an event that resulted in injuries to a person or persons. ***Near Miss*** is an event that could have caused an accident

SECTION I: EMPLOYEE INFORMATION			
1. I am reporting a(n): ○ accident ○ near miss.		**2. Date of accident/near miss:**	
3. Have you told your supervisor about this accident/near miss? ○Yes ○No		**4. Time of accident/near miss:**	
5. Did this injury occur while you were working? ○Yes ○No		**6. Were there three (3) or more employees injured in this event?** ○ Yes ○ No ○Don't Know	
THIS QUESTION IS FOR EMPLOYEES ONLY **7. If you had a work related accident, have you called and reported it to AmeriSys at 800-455-2079? ○ Yes ○ No**			
8. I am a(n): ☐ Regular full time employee ☐ Regular part time employee ☐ Working Student ☐ Temporary employee ☐ Volunteer ☐ Other			
9. Employee Job Category: ☐ Housekeeping ☐ Laboratory ☐ LNR ☐ Law Enforcement ☐ Maintenance ☐ Office ☐ Teaching ☐ Other			
10. Employee Name:	**11. Employee Job Title:**	**12. Employee Phone Number:**	
13. Supervisor Name:	**14. Supervisor Job Title:**	**15. Supervisor Phone Number:**	
16. Date of Employment/Hire?	**17. Age Range:** ☐ 18-24 ☐25-34 ☐35-44 ☐45-54 ☐55-64 ☐65+	**18. Did death occur?** ○ Yes ○No	
SECTION 2: ACCIDENT / NEAR MISS INFORMATION			
19. Were tools, equipment, vehicles, or other objects involved? ○Yes ○No ○Don't Know	**19a. If yes, what was it?**	**20. Choose all that apply as a result of the event:** ☐First Aid ☐Reporting ☐Workman Comp ☐Days Off ☐Light Duty	
21. Were any motor vehicles involved? ○ Yes ○No	**21a. Motor Vehicle owner:** ☐State ☐Student ☐Faculty/Staff ☐Contractor ☐Others ☐Not Applicable	**21b. Motor Vehicle 1 License Plate / Registration #**	
21c. Motor Vehicle 2 License Plate / Registration #	**22. Is there Property Damage involved?** ○ Yes ○No	**22a. What property was damaged?**	
23. Names of witnesses (if any):			
24. Provide the specific building, room, area, and street in which the event occurred:			
25. What were you doing at the time?			
26. Describe step by step what led up to the accident/near miss.			

27. What could have been done to prevent this accident/near miss?

28. Has the employee been trained in safety practices related to this event? ○Yes ○No ○Don't Know. If yes, when?_____/___/_____

29. Has the employee been trained in the use of Personal Protective Equipment related to this event? ○Yes ○No ○Don't Know

○ Not Applicable If yes, when?_____/___/_____

30. Was the employee wearing Personal Protective Equipment at the time of the accident? ○Yes ○No ○Don't Know ○ Not Applicable

30a. Protective Eye Wear	**30b. Hard Hat**	**30c. Safety Shoe**	**30d. Goggles**	**30e. Gloves**	**30f. Hearing Protection**	**30g. Respiratory Protection**
☐ Safety Glasses ☐ Prescribed Glasses with Side Shield ☐ Other	☐ Plastic ☐ Metal ☐ Other	☐Toe Protection ☐Electrical ☐Slip Resistant ☐Other	☐ Dust ☐ Chemical ☐ Other	☐ Nitrile ☐ PVC ☐ Cotton ☐ Leather ☐ Natural Rubber ☐ Electrical ☐ Other	☐ Ear Muff ☐ Ear Plugs ☐ Other	☐ Disposable Dust Mask ☐ Full Face ☐ Half Face ☐ Other

31. If this is a near miss, how could you or someone else have been injured?

32. <u>To Be Completed by Supervisor:</u> What corrective action(s) have you implemented since the injury or near miss to protect the employee? (or comments/suggestions)

SECTION 3: SUPERVISOR ACKNOWLEDGES EVENT

33. ☐ Supervisor: I have read and completed this report based on my notes, employee assistance, or other means.

33a. Supervisor Signature:	**33b. Date:**	**33c. Supervisor Email:**

34. ☐ Acknowledgement: I acknowledge the information is accurate and completed to the best of my knowledge.

34a. Employee Signature:	**34b. Date:**	**34c. Email:**

35. Signature of individual Completing Report (*If not Employee or Their Supervisor*):

Appendix K- Eyewear and Equipment Vendors

Laser Safety Eyewear and Equipment Vendors

Company / Vendor Name	Location	Contact Information
Kentek Corporation	5 Jarado Way Boscawen, NH 03303 United States	+1-603-223-4900 800-432-2323 info@kenteklaserstore.com
Thorlabs Inc.	43 Sparta Ave Newton, New Jersey 07860 United States	P: 1-973-300-3000 F: 1-973-300-3600 E: sales@thorlabs.com
Laser Safety Industries	Minneapolis, MN	1-888-752-7370 https://lasersafetyindustries.com/pages/contact-us info@lasersafetyindustries.com
LaserVision USA	Address: 595 Phalen Boulevard, St. Paul, MN 55130	Email: info@lasersafety.com Phone: 800-393-5565 International: +1-651-357-1800 Fax: 651-357-1830
Phillips Safety Products, Inc.	271 Lincoln Blvd Middlesex, NJ 08846	Phone: 1-833-238-6353 Fax: 732-356-7127 Email: service@phillips-safety.com
LaserTech	11410 Interchange Circle North Miramar Florida 33025	Toll-Free: 855-527-3700 855-LASER-00 Office: 954-380-5060 E-mail: sales@laser-tech.com
Dioptika Laser & IPL Safety Solutions	32 Winding Brook Dr, Sinking Spring PA 19608, USA	877-712-2181 info@dioptika.com
Innovative Optics	8211 Blaikie Ct, Sarasota, FL 34240	763-425-7789 sales@innovativeoptics.com

Appendix L- Frequently Asked Questions for Lasers

If I relocate a laser, do I need to contact Environmental Health and Safety?

Yes, relocation of a laser requires an updated registration with the Florida Department of Health to be sent in (DH 1605). If you plan to relocate a laser to a new room or building, please complete the EHS laser registration form (LS-1)

I do not know if my laser is registered with the State of Florida Bureau of Radiation Control, who do I need to contact?

You can contact the designated Laser Safety Officer, Mario.DeVera@ucf.edu , Phone:407 823 0476 to find out if your device has been registered. If it has not, EHS can help you initiate this process.

Do Principal Investigators have to go through Laser Safety Training?

PIs must take the Safety Training for PIs course. In this course, Laser Safety will be covered. PIs may take the online training provided by EHS if they want to see what information their students are receiving.

What does the Laser Safety Training at UCF entail?

Laser Safety Training is offered online for students and lab workers as part of requirement to qualify as authorized user.

I do not have enough safety glasses for temporary volunteers in my lab, what do I need to do?

Contact EHS. We will reach out to other laser users and vendors to see if we can find you an economical solution.

How often does UCF Environmental Health and Safety inspect my laboratory?

Annually.

What are the inspection checkpoints that I need to be aware of for the laser portion of the inspection?

See *Appendix I, (Laser Inspection Checklist)* of the Laser Safety Manual.

How often do I need to update my laser inventory with Environmental Health and Safety?

Annually.

I have purchased a new laser. What next?

Contact EHS at ehs@ucf.edu or thru the designated LSO at Mario.DeVera@ucf.edu. Fill out a *Laser Registration Form (LS-1, Appendix D)* and send it to EHS via email. We will complete the *DH 1605 form* and mail it to the Florida Department of Health for you. Once a certified DH1605 is returned from the Florida Department of Health, EHS will send you a copy to post outside of the laser use area.

Do I need an SOP for every laser in my laboratory?

Yes, every class 3B and 4 laser must have an accompanying SOP *(See Appendix C)*.

How often do my lab workers need to go through laser safety training?

Currently, Laser Safety Orientation (EHS 309) this is a one-time training. However, in the near future annual refresher training will be implemented with annual updates. If PIs want their students to take an annual refresher, updated questions can be formed to meet the safety needs of the lab.

What documentation must be in my Laser Safety Manual?

A copy of your laser inventory or your DH 1605 and SOPs. Signed *LS-3 Forms (Written Certification Form)* by each laser worker

References

The following sources were consulted and referenced during the development of the UCF Laser Safety Manual:

[1] Edwards, B., A Comprehensive Laser Safety Program for the Research University Setting. *Operational Radiation Safety* **83**:S32-S35; 2002.

[2] American National Standards Institute. ANSI Z136.1-2014 American National Standard for Safe Use of Lasers. Orlando, FL: Laser Institute of America; 2014.

[3] American National Standards Institute. ANSI Z136.8-2012 American National Standard for Safe Use of Lasers in Research, Development, or Testing. Orlando, FL: Laser Institute of America; 2012.

[4] Florida Department of Health, Bureau of Radiation Control

[5] Food and Drug Administration (FDA), *Code of Federal Regulations, Title 21, Part 1040.10*

[6] United States Department of Labor- Occupational Safety and Health Administration Technical Manual, Section III: Chapter 6

[7] The University of Central Florida, College of Optics and Photonics

[8] Allen, R.G., Labo, J.A., and Mayo, MW. (1990) Laser eye protection. *Laser Safety, Eyesafe Laser Systems, and Laser Eye Protection* **1207**, 34-45.

[9] Sliney, D.H. and Wolborsht, M.L. (1980) Safety Standards and Measurement Techniques for High Intensity Light Sources. *Vision Res* **20**, 1133-1141.

[10] Drawing of the Eye- National Eye Institute, National Institutes of Health

[11] University of Central Florida Laboratory Safety Manual

[12] University of Arizona Laser Reference Guide

[13] Duke University, Laser Safety Program

[14] Julie Donnelly, Chemistry Laser User, Photograph taken by Carlos Diaz, Dr. F. Eloy Hernandez Laboratory, University of Central Florida