



University Of South Florida Laser Safety Manual

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Safety Fact

The most common causes of laser accidents in research labs are the following:

- (1) Not wearing appropriate safety goggles*
- (2) Not reducing power for alignment procedures, or unintended power increase*
- (3) Stray beams left uncontained by beam stops or other barriers*



UNAUTHORIZED PERSONNEL KEEP
Class 3B and 4 laser product(s)

1. Introduction to the USF Laser Safety Program

The University of South Florida (USF) laser safety program provides guidance to the USF community on the safe user of lasers. Principal Investigators (PI) administering a laser program must be familiar with the following topics covered in the manual:

- Registration of Class 3B and Class 4 lasers
 - Training and documentation for all users of Class 3B and Class 4 lasers
 - Evaluation of each laser for proper control measures, including required postings and personal protective equipment (PPE).
 - Completion of laser hazard evaluations
- The regulation of LASERs falls under the rules of the State of Florida administrative code (FAC) 64E-4, Control of Nonionizing Radiation. FAC 64E-4 recognizes ANSI Z136.1 (2014) "Safe Use of Lasers" as the industry standard. This directive and ANSI Z136.1 "Safe Use of Lasers" and/or ANSI Z136.8 (2012) "Safe Use of Lasers in Research and Development and Testing" are used as the basis for the USF Laser Safety Program.

See Appendix A for a glossary of terms and abbreviations used in this document.

LASERs	Light A mplification by S timulated E mission of R adiation. A laser produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels.
Class 1	Poses no threat of biological damage.
Class 1M	May pose a threat if viewed with optical devices.
Class 2	Visible (0.4 to 0.7 μm) output, eye protection is normally afforded by aversion response.
Class 2M	Visible (0.4 to 0.7 μm) output, may pose a threat if viewed with optical devices
Class 3	Medium powered lasers – may be hazardous under direct or specular viewing, not normally a diffuse reflection or fire hazard.
Class 3R	Has potential hazards, under some direct or specular viewing conditions
Class 3B	Can cause biological damage to the eyes.
Class 4	High powered lasers -direct exposure to primary beam, specular reflections and diffuse reflections can cause biological damage to the eyes or skin. Laser beam may have potential to generate a fire hazard. Laser beam may generate air contaminants.

2. Responsibilities and Program Administration

Laser Safety Committee (LSC) serves as the advisory group advising the Senior Vice-President for Research & Innovation on all matters pertaining to the safe handling of hazardous lasers at the University of South Florida. See Appendix H.

The Laser Safety Officer (LSO) is appointed by the Senior Vice-President for Research & Innovation. The LSO has the following responsibilities:

1. Provide assistance in evaluating and controlling hazards.
2. Maintain records of lasers and register class 3b and 4 lasers with the State of Florida, Department

- of Health-Bureau of Radiation Control.
3. Participate in accident investigations involving lasers.
 4. Provide general laser safety training.
 5. Perform semi-annual inspections of class 3b and 4 lasers in use at USF.
 6. Suspend any laser operation that constitutes a hazard to laser operator, USF student or member of general public.
 7. Recommend medical evaluation after laser exposure incidents.
 8. Establish procedures to investigate all incidents with potential or actual employee exposure to laser radiation.
 9. Assist the USF Laser Safety Committee with its responsibilities.

Principle Investigator (PI)

Principal Investigators are directly responsible for laboratory laser safety, and implementing a safety program as prescribed in this manual and in consultation with the LSO. This includes the implementation of hazard controls, oversight and management of non-laser hazards, and informing the LSO of any changes that affect the laser users. It is also the responsibility of the PI to ensure that all laser users have met the training requirements.

1. Maintain procedure(s) for the safe use of all class 3B and 4 lasers in lab. (see appendix G for a template for SOPs)
2. Provide any necessary safety equipment to ensure safe use of laser.
3. Register all class 3b and class 4 lasers purchased or acquired with the USF LSO.
4. Be knowledgeable of the potential laser hazards and associated control measures for all lasers under their control.
5. Immediately report known or suspected accidents to USF supervisor and LSO.
6. Ensure that lasers under their control are not operated or modified without prior approval.
7. Ensure that all safety related administrative and engineering controls are in place.
8. Maintain inventory control and a permanent record of the status of all Class 3b, and Class 4 lasers.
9. Ensure that individuals working with lasers have completed the required laser safety training and provide laser operators with training in the administrative, alignment, standard operating procedures and emergency instructions.

Since the PI is ultimately responsible for laboratory laser safety, failure to follow the guidance provided in this manual may result in disciplinary actions as recommended by the Laser Safety Committee.

Laser Personnel

1. Attend/complete required USF laser safety training.
2. Be familiar with specific safety hazards of lasers in lab area.
3. Follow operating and emergency procedures established by your principal investigator.
4. Use Class 3b or Class 4 lasers only if specifically authorized and hazards are understood.
5. Report known or suspected accidents to the principal investigator and USF LSO
6. Inform lab visitors about and protect any spectators from all potential laser hazards.

3. Training and Qualifications

Individuals who work with or in close proximity to Class 2, 2M, 3, or 3R lasers should complete laser safety training provided by USF LSO. Review the USF Laser Safety Manual and complete the Laser Safety Program's Laser Safety Training found online (<http://www.research.usf.edu/dric/radiation-safety/docs/laser-safety-training.pdf>).

The PI is responsible for verifying training status of all operators. Before operating a Class 3B or Class 4 laser, all personnel shall review the USF Laser Safety Manual and complete the Laser Safety Program's Laser Safety Training found online (<http://www.research.usf.edu/dric/radiation-safety/docs/laser-safety-training.pdf>).

This training covers:

- Fundamentals of laser operation.
- Laser hazards
- Classification of lasers and laser systems.
- Control measures and personal protective equipment.

Individuals who work with or in the same lab area containing a Class 3b or Class 4 lasers shall receive additional training from principal investigator (USF LSO can assist as needed). PI shall maintain training records and the training shall include:

- Operating and emergency procedures for laser(s) in use.
- Relations of specular and diffuse reflections.
- Proper use of protective equipment – (e.g. safety interlocks, eyewear, etc.)
- Maximum personal exposure levels for eye and skin.
- Laser hazard evaluations and range equations.
- Review the operating and safety instructions furnished by the manufacturer

4. Laser Acquisition, Transfer and Disposal

A. Registration of new laser machines

All Class 3B and Class 4 lasers must be registered with the USF Laser Safety Program. Registration can be completed using the online Laser Registration Form in appendix B. The LSO must be notified when significant modifications are made to the original laser or work area. The LSO will conduct a hazard evaluation of the laser work area and make necessary recommendations.

B. Transfer and Surplus

The LSO must be notified when a Class 3B or Class 4 laser is transferred from one PI to another PI on-campus, or if the laser is sold or transferred within or from USF.

C. Disposal

- a) Several considerations should be given when disposing of a laser – making the laser inoperative, removing it from inventory, and proper disposal of any hazardous waste that may be involved.
- b) Under no circumstances shall Class 3B or Class 4 lasers be abandoned. **Contact the USF LSO for guidance to properly disposal of a laser system.**

5. Control Measures – General

Control measures shall be devised to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and other hazards associated with lasers during operation, service and maintenance. The LSO will evaluate and monitor laser hazards and appropriate control measures.

1. Lasers should be operated in well-lighted areas whenever possible to reduce pupil size and minimize possible eye damage.
2. Jewelry must not be worn in a laser controlled area as laser beams may reflect off the jewelry and cause damage to the eyes or skin.
3. Materials capable of specular reflection should be avoided or removed from the laser operating area.
4. The laser beam must never be intentionally stared into or directed into the eyes.
5. If the laser operator suspects that a safety hazard may exist, the operators should STOP WORK and request the Laser Safety Officer to conduct an immediate laser safety inspection.
6. Each laser and laser facility must be designed to ensure that maximum protection is afforded to the operator.
7. Only Class 1, Class 2, and Class 3R lasers may be used for educational demonstration purposes unless approved by USF LSO.

Control methods can be divided into three areas, in order of preference:

1. **Engineering controls**, such as barriers, beam blocks, interlocks, etc.
2. **Administrative controls**, such as training, signs, labels, procedures, etc.
3. **Personal protective equipment (PPE)**, such as laser protective eyewear and skin coverings.

In most cases the requirements for control measures are based on the hazard classification of the laser radiation that is accessible during operation, maintenance, or service. After review and approval of the LSO, the control measures specified in this section may be replaced by other controls that provide equivalent protection.

Summary of Required Control Measures at USF	
Class 1	Exempt from any control measures for laser radiation
Class 1 Embedded Laser Systems	Exempt from any control measures, except for the case when operating with any factory interlocks or other safety features defeated requires hazard evaluation and approval by the LSO
Class 1M	Exempt from any control measures except when using optically aided (“magnified”) viewing, and/or the beam is operated unattended into a location where it can be directly viewed by personnel uninformed about the hazards
Class 2	Exempt from any control measures except during intentional direct viewing of the beam.
Class 2M	Exempt from any control measures except during intentional direct viewing of the beam, and/or potential for directly viewing the optically aided (“magnified”) beam.
Class 3R <i>Class 3A</i>	Exempt from any control measures or other forms of surveillance except for conditions when directly viewing the beam or its specular reflection, and/or unattended operation with the beam directed into a location where it can be directly viewed by personnel uninformed about the hazards. Follow the manufacturer’s safety instructions.

Class 3B and Class 4	Requires approval of appropriate control measures by the LSO to reduce the risk of hazardous exposure to the eye or skin from the direct and reflected beam. Class 4 lasers may require additional protection from diffusely reflected beams, potential skin hazards, fire hazards and non-beam hazards such as Laser Generated Airborne Contaminates (LGAC) and plasma radiation.
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A. Minimum requirements for Class 3B and Class 4 indoor laser controlled areas:

1. Shall be controlled such that lasers and laser systems are operated only by personnel who have been trained in laser safety and in the operation of the laser or laser system.
2. Shall be posted with the appropriate area warning sign(s), posted in conspicuous locations to warn onlookers.
3. Shall be operated in a manner such that the beam path is well defined.
4. Require the appropriate eye protection for personnel within the laser-controlled area.
5. Use the lowest laser power possible for beam alignment procedures.

B. Additional requirements for Class 4 lasers, and recommended for Class 3B lasers:

1. Shall be under the direct supervision of an individual knowledgeable in laser safety.
2. Shall be located so that access to the area by spectators is limited and requires approval. This may require interlocks on access doors.
3. Have any potentially hazardous beam terminated in a beam stop of an appropriate material.
4. Where feasible, have only diffusely reflecting material in or near the beam path. There shall be no unnecessary specular reflecting surfaces or tools near the beam path.
5. Have the laser secured such that the exposed beam path is above or below eye level of a person in any standing or seated position, if possible.
6. Have all windows, doorways, open portals, etc., from an indoor facility either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the applicable ocular MPE.
7. Require storage or disabling (e.g., removal of the key, password controlled, or lock-out/tag-out) of the laser or laser system when not in use to prevent unauthorized use.

C. Control measures for Class 3B and Class 4 lasers used outdoors:

1. The LSO shall affect a laser hazard analysis to establish the nominal hazard zone (NHZ) and a laser-controlled area (LCA). The requirements for indoor LCA shall apply to the outdoor LCA, as applicable.
2. Under no circumstances will visible laser beams be directed toward automobiles, aircraft, or other manned structures or vehicles, or otherwise disrupt critical tasks.

6. Control Measures – Signs and Labels

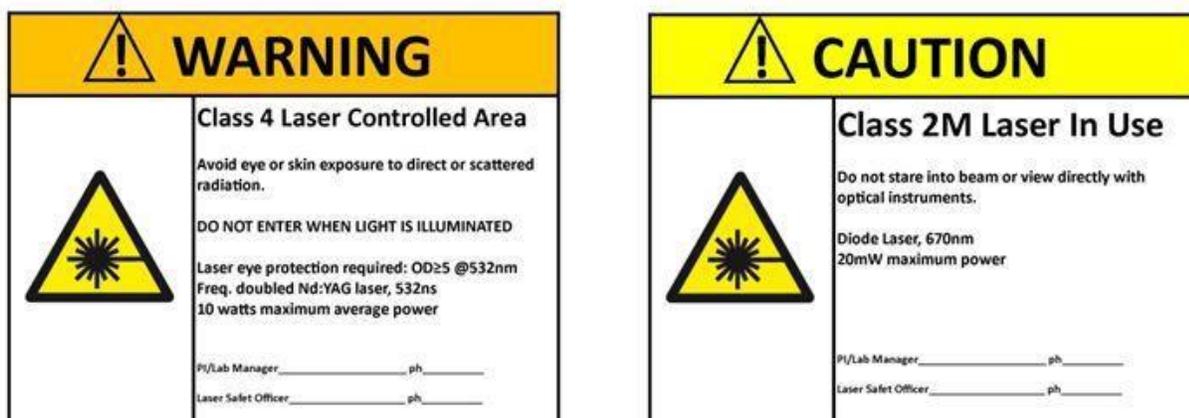
- A. Required laser hazard signs shall be conspicuously displayed in locations where they will best serve to warn onlookers. All access doors to rooms that contain Class 3B or 4 lasers are to be posted with a laser hazard sign. Laser hazard signs may be posted for Class 2 and Class 3A/3R lasers, but are not required
- B. Signal words "Caution", "Warning" and "Danger" for hazard signs are assigned as follows:
 1. "**CAUTION**" indicates a hazardous situation that, if not avoided, could result in minor or moderate injury. The signal word "CAUTION" shall be used with all signs and labels associated with Class 2, 2M and 3R lasers. "CAUTION" should be printed in black letters on a yellow background.
 2. "**WARNING**" indicates an imminently hazardous situation that, if not avoided, could result in death or serious injury. The signal word "WARNING" shall be used on laser area warning signs associated with lasers and laser systems whose output exceed the MPE for irradiance, including all Class 3B and Class 4 lasers and laser systems. "WARNING" should be printed in black letters on an orange background.
 3. Note: the "**DANGER**" signal word is restricted to Class 4 lasers with high (multi-kW) output power or pulse energies with exposed beams, and indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury.
 4. The signal word "**NOTICE**" is not appropriate or allowed on signs warning of a laser hazard or hazardous situation, instead use "CAUTION" or "WARNING" in these situations.

Required warning signs shall include the following information, as applicable:

1. The hazard class of the laser controlled area
2. Name and contact information for PI and LSO

Laser hazard signs that meet previous ANSI sign standards are allowed because they have been "grandfathered" in to the current 2014 standards. (Contact USF LSO with questions or to produce signs for your lab)

Examples of signs that meet the ANSI (2014) standard:



Labels on Laser Housing – Lasers should be labeled by the manufacturer with the following:

1. Class of laser
2. Wavelength, pulse duration, and maximum output power.

3. Precautionary statements for users, such as
 - a) For Class 2 lasers, “Laser Radiation-Do Not Stare into Beam”
 - b) For Class 2M lasers, “Laser Radiation-Do Not Stare Into Beam or View Directly with Optical Instruments”
 - c) For Class 3R and Class 3B lasers, “Laser Radiation-Avoid Direct Eye Exposure to Beam”
 - d) For Class 4 lasers, “Laser Radiation-Avoid Eye Exposure to Direct or Scattered Radiation; Avoid Skin Exposure to Direct Radiation”

7. Control Measures – Standard Operating Procedures (SOP)

An SOP is required for Class 3B and Class 4 lasers. The SOP shall document procedures for alignments, maintenance and normal operations. The SOP shall include any LSO approved variations from control measure, such as procedures, PPE, administrative or engineering controls used in place of requirements in the ANSI standards. The SOP shall be revised by a laser users working with class 3b and/or class 4 lasers and may serve as a training document for new users.

See appendix G for a template when developing a SOP.

8. Control Measures – Protective Equipment

- A. Engineering controls shall be given primary consideration in instituting a control measure program for limiting access to laser radiation. Enclosure of the laser equipment and the beam path, or remote viewing and operation are the preferred methods of control to isolate or minimize the hazard. When engineering controls are impractical or inadequate, administrative and procedural controls and PPE shall be used, and requirements documented in the laser SOP.
- B. The Principal Investigator is responsible for ensuring that the appropriate PPE is available and worn. Laser operators are responsible for properly using all required protective equipment.
- C. Availability and Use of Laser Safety Eyewear
 1. Laser safety eyewear shall be available and worn by laser operators, attendants and visitors in laboratories where a Class 3B or Class 4 laser is present and there is a potential exposure to the beam or reflected beams at levels above the MPE. Laser eyewear must comply with ANSI Z136.1 requirements
 2. Laser safety eyewear is not required for Class 2, Class 2M or Class 3R/3A lasers unless intentional long-term (>0.25 seconds) direct viewing is required. USF LSO shall approve any lasers operations that require intentional long-term viewing.
- D. Laser safety eyewear shall be chosen based on the level of protection needed to protect the eyes from a worst case scenario. The USF LSO can assist with selection of proper laser eyewear for your research. The following information is needed when selecting appropriate laser safety eyewear:
 1. Wavelength(s)
 2. Mode of operation (continuous wave or pulsed)
 3. Maximum exposure duration (assume worst case scenario)

4. Maximum irradiance (W/cm^2 for CW) or radiant exposure (J/cm^2 for pulsed)
5. Maximum permissible exposure (MPE)
6. Optical density (OD)

One pair of laser safety eyewear may not be sufficient when working with tunable or multiple wavelength lasers. Always check the OD and wavelength prior to use. Eyewear with multiband filters and flip-up eyewear are available for some applications.

For ultra-fast (femtosecond) lasers, temporary bleaching may occur from high peak irradiances from ultra-fast laser pulses. Contact the manufacturer of the laser safety eyewear for test data to determine if the eyewear will provide adequate protection before using them.

E. Other considerations for laser safety eyewear:

1. Visible light transmission (VLT)
2. Effect on color vision
3. Field of view provided by the design of the eyewear
4. Reversible bleaching of absorbing media
5. Need for prescription lenses
6. Fit and comfort
7. Impact resistance
8. Glass laser eyewear is heavier and more costly than plastic, but it provides better visible light transmittance. There are two types of glass lenses, those with absorptive glass filters and those with reflective coatings. Reflective coatings can create specular reflections and the coating can scratch, minimizing the protection level of the eyewear.
9. Polycarbonate: Polycarbonate laser eyewear is lighter, less expensive and offers higher impact resistance than glass, but allows less visible light transmittance.
10. Diffuse Viewing Only (DVO): As the name implies, DVO eyewear is to be used when there is a potential for exposure to diffuse reflections only. DVO eyewear may not provide protection from the direct beam or specular reflections.

F. Alignment Eyewear: Alignment eyewear may be used when aligning low power visible laser beams. Alignment eyewear transmits enough of the specified wavelength to be seen for alignment purposes, but not enough to cause damage to the eyes. Alignment eyewear cannot be used during operation of high power or invisible beams and cannot be used with pulsed lasers.

G. Labeling of Laser Safety Eyewear - Laser safety eyewear shall be labeled with the optical density and the wavelength(s) the eyewear provides protection for. Additional labeling may be added for quick identification of eyewear in multiple laser laboratories. Must be labeled to meet ANSI Z136.1 (4.4.4.2.6) requirements

H. Inspecting laser safety eyewear, check for:

1. Pitting, crazing, cracking and discoloration of the attenuation material.
2. Mechanical integrity of the frame.
3. Light leaks.
4. Damage to the lens coating.
5. Use care when cleaning eyewear and follow manufacturers' instructions to avoid damage to absorbing filters or reflecting surface.

9. Ultraviolet (UV) Laser Protection

- A. Particular care shall be taken when using UV lasers due to the potential for significant photochemical bio-effects and the high level of scattering of UV radiation by air molecules. UV radiation may produce undesirable reactions, for example formation of skin sensitizing agents, ozone and other Laser Generated Airborne Contaminates (LGAC). Chronic eye and skin exposure to UV radiation may have long term adverse health effects which are not fully understood.
- B. Exposure to UV radiation shall be minimized by using beam shields and clothing that attenuate the radiation to levels below the MPE for the specific UV wavelengths. For example, for an excimer laser operating in the UV, the use of a skin cover shall be employed if chronic (repeated) exposures are anticipated at exposure levels at or near the applicable MPE's for skin.

10. Non-Beam Hazards

Non-beam hazards often exist in laser-related operations and can pose significant health and safety risks. All non-beam hazards must be addressed in SOPs. Examples of non-beam hazards may include:

- A. Electrical hazards from power supplies
- B. Laser generated air contaminants (LGAC), which may be generated when a Class 4 or some Class 3B lasers interact with matter. Materials such as plastics, composites, metals and biological tissues may release toxic, noxious or carcinogenic air contaminants. Ozone is produced around flash lamps and can build up with high repetition rate lasers.
- C. Fire hazards from Class 4 lasers
- D. Compressed gases
- E. Laser dyes and solvents may contain complex fluorescent organic compounds.

11. Laser Hazard Evaluation

- A. Each laser installation will have hazards unique to that installation. Hazard considerations include optical hazards, skin hazards such as UV radiation, high voltages, ozone generation, toxic chemicals and gases (LGAC), etc.
- B. A laser hazard evaluation shall be performed to identify all hazards associated with a laser or laser system and to determine the necessary control measures. The PI should contact the LSO for assistance in performing the hazard evaluation. The following hazards should be evaluated for each laser installation:
 - 1. The laser and laser system's capability of injuring personnel
 - 2. The environment in which the laser is used
 - 3. The personnel who may use or be exposed to laser radiation

12. Exposure Incidents

Notify the PI and LSO when exposure incidents occur. In the case of suspected eye injury from a laser, the LSO may require an eye examination by a qualified medical expert to evaluate laser induced eye injury. If medical attention is needed:

For USF Personnel:

Contact AmeriSys at 800-455-2079 (24 hours a day/7 days a week) during working hours (M-F, 8-5 PM) the USF Worker's Compensation Insurance Specialist should also be contacted at 813-974-5775, or melridge@usf.edu

For Non-USF Personnel:

Seek medical attention in the event of an exposure or suspected exposure to laser radiation capable of an eye or skin injury.

Florida Administrative Code - 64E-4.011 Notification and Reports of Incidents.

(1) Immediate Notification. Each registrant shall notify the Department immediately by telephone at (407) 297-2095 of any incident involving any source of laser or collateral radiation possessed by the registrant and which has or may have caused:

(a) An exposure to an individual of greater than 100 times the MPE limits of laser or collateral radiation; or

(b) An exposure to an individual which involves the partial or total loss of sight in either eye; or

(c) An exposure to an individual which involves perforation of the skin or other serious injury exclusive of eye injury.

(2) Twenty-four Hour Notification. Each registrant shall notify the Department by telephone at (407)297-2095 within 24 hours of any incident involving any source of laser or collateral radiation possessed by the registrant and which has or may have caused:

(a) An exposure to an individual of greater than five times the MPE limits of laser or collateral radiation; or

(b) An exposure to an individual with second- or third-degree burns to the skin or potential injury and partial loss of sight.

(3) Each registrant shall make a report in writing within 30 days to the Department of:

(a) Each exposure of an individual to laser and collateral radiation in excess of the MPE limits,

(b) Any incident for which notification is required by subsection 64E-4.011(1) or (2), F.A.C., above.

(4) Each report required by subsection 64E-4.011(3), F.A.C., above, shall describe the extent of exposure of individuals to laser or collateral radiation, including estimates of each individual's exposure; levels of laser or collateral radiation involved; the cause of the exposure; and corrective steps taken or planned to be taken to assure against a recurrence.

(5) Any report filed with the Department pursuant to subsection 64E-4.011(3), F.A.C., above, shall include the full name of each individual exposed, an estimate of each individual's exposure and a description of any injuries. The report shall be prepared so that this information is stated in a separate part of the report.

(6) When a registrant is required to report to the Department any exposure of any individual to laser or collateral radiation, the registrant shall also provide to the individual a report on the exposure data included therein. Such reports shall be transmitted at a time not later than the date of transmittal to the Department.

ANSI Z136.1 “ANSI Standard for Safety User of Lasers”, Appendix F, provides guidance for medical referral following suspected or known laser injury. This Standard does not recommend a medical surveillance program for laser users e.g. pre-screening for laser workers (ANSI Z136.1 Appendix F3).

Appendix A: Glossary

A few common terms – for more information contact USF LSO

Administrative Control Measures

Procedures, training and warning signs designed to inform personnel to safety work near laser radiation.

ANSI Z136.1 (2014) and ANSI Z136.8 (2012)

American National Standard for Safe Use of Lasers Series - These documents are the regulatory laser protection standard in the US. The USF Laser Safety Manual is based on these standards.

Aversion Response (Blink Response)

Closure of the eyelid, eye movement, pupillary constriction, or movement of the head to avoid an exposure to a noxious or bright light stimulant. The aversion response to an exposure from a bright, visible, laser source is assumed to limit exposure of a specific retinal area to 0.25s or less.

Collecting Optics

Lenses or optical instruments having magnification and that may produce an increase in energy or power density of laser. Such devices may include telescopes, binoculars, microscopes, or loupes. Collecting optics is a hazard in laser labs, and requires particular attention when used around Class 1M or 2M lasers.

Continuous Wave (CW)

A laser operating with a continuous output for a period > 0.25 s is regarded as a CW laser.

Control Measure

A means to mitigate potential hazards associated with the use of lasers. Control measures can be divided into three groups: engineering, administrative (procedural), or personal protective equipment (PPE).

Cornea

The transparent outer layer of the human eye which covers the iris and the crystalline lens. The cornea is the main refracting element of the eye.

Critical Frequency

The pulse repetition frequency above which the laser output is considered continuous wave (CW). For example, for a short unintentional exposure (0.25 s to 10 s) to nanosecond (or longer) pulses, the critical frequency is 55 kHz for wavelengths between 0.40 and 1.05 μm , and 20 kHz for wavelengths between 1.05 and 1.40 μm .

Diffuse Reflection

Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium. A diffuse reflector will cause the reflected laser radiation to be spread over a wider area, and have a significantly reduced hazard level compared to the direct laser beam (see "Specular Reflection")

Divergence

The divergence is the increase in the diameter of the laser beam with distance from the exit

aperture, based on the full angle at the point where the irradiance (or radiant exposure for pulsed lasers) is $1/e$ times the maximum value. Symbol: ϕ

Embedded Laser

An enclosed laser that has a higher classification than the laser system in which it is incorporated, where the system's lower classification is appropriate due to the engineering features limiting accessible emission. Many laser cutters are Class 4 lasers in a Class 1 laser enclosure, and require no special laser safety precautions as long as the factory installed safety features remain intact.

Enclosed Laser

A laser that is contained within a protective housing of itself or of the laser or laser system in which it is incorporated. Opening or removing of the protective housing provides additional access to laser radiation above the applicable MPE than possible with the protective housing in place (an embedded laser is an example of one type of enclosed laser).

Engineering Control Measure

Key controls, interlocks, beam housings, shutters, etc. designed to prevent exposure to hazardous levels of laser radiation. Engineering controls are considered the most effective laser safety control measures.

Erythema

Redness of the skin due to exposure from laser radiation

Eye-safe Laser

A Class 1 laser product. Because of the frequent misuse of the term "eye-safe wavelength" to mean "retina-safe," (e.g., at 1.5-1.6 μm) and eye-safe laser to refer to a laser emitting at wavelengths outside the retinal-hazard region, the term "eye-safe" can be a misnomer. Hence, the use of eye-safe laser is discouraged.

Fail-safe Interlock

An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

Intrabeam Viewing

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

Iris

The circular pigmented structure which lies behind the cornea of the human eye. The iris is perforated by the pupil.

Irradiance

Radiant power incident per unit area upon a surface, expressed in watts-per-centimeter-squared (W/cm^2). Symbol: E

Laser

Light **A**mplification by **S**timulated **E**mission of **R**adiation. A laser produces an intense, coherent (temporally, or

spatially, or both), directional beam of light by stimulating electronic or molecular transitions to lower energy levels.

Laser Barrier

A device used to block or attenuate incident direct or diffuse laser radiation. Laser barriers are frequently used during times of service to the laser system when it is desirable to establish a boundary for a controlled laser area.

Laser Classification

An indication of the beam hazard level of a laser or laser system during normal operation. The hazard level of a laser or laser system is represented by a number or a numbered capital letter. The laser classifications are Class 1, Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4. In general, the potential beam hazard level increases in the same order. (see Appendix D)

Laser Controlled Area (LCA)

An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from laser radiation hazards. The Nominal Hazard Zone (NHZ) is within the LCA.

Laser-Generated Air Contaminants (LGAC)

Air contaminants generated when Class 4 and some Class 3b laser beams interact with matter. The quantity, composition and chemical complexity of the LGAC depend on the target material, cover gas and beam irradiance. Materials such as plastics, composites, metals and tissues may release carcinogenic, toxic and noxious air contaminants. Ozone is produced around flash lamps and can build up with high repetition rate lasers. Special optical materials used for far infrared windows and lenses may also release hazardous air contaminants.

Laser personnel

USF personal that operates or works around hazardous laser beams.

Laser Pointer

A laser product that is usually hand held that emits a low-divergence visible beam and is intended for designating specific objects or images during discussions, lectures or presentations as well as for the aiming of firearms or other visual targeting practice. These products are normally Class 1, Class 2 or Class 3R.

Laser Safety Officer (LSO)

One who has authority and responsibility to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

Laser System

An assembly of electrical, mechanical, and optical components which includes a laser

Macula

The small uniquely pigmented specialized area of the retina of the eye, which, in normal individuals, is predominantly employed for acute central vision (i.e., area of best visual acuity).

Magnified Viewing

Viewing a small object through an optical system that increases the apparent object size. This type of optical system can make a diverging laser beam more hazardous (e.g., using a magnifying optic to view an optical fiber with a laser beam emitted).

Maximum Permissible Exposure (MPE)

The level of laser radiation to which an unprotected person may be exposed without adverse biological changes in the eye or skin. The MPE is useful in laser safety calculations, such as determining the nominal hazard zone (NHZ).

Nominal Hazard Zone (NHZ)

Exposure within the boundary of the NHZ to direct, reflected, or scattered laser radiation has the potential to exceed the MPE and thus cause injury. Exposures beyond the boundary of the NHZ are below the MPE, and unprotected exposure will not cause damage to the eye or skin.

Nominal Ocular Hazard Distance (NOHD)

The distance along the axis of the unobstructed beam from a laser, fiber end, or connector to the human eye beyond which the irradiance or radiant exposure is not expected to exceed the applicable MPE.

Non-beam Hazard

A class of hazards that result from factors other than direct human exposure to a laser beam. Examples include electrical hazards, compressed gases, chemical hazards from dyes or solvents, sharp objects and fire hazards.

Ocular Fundus

The interior posterior surface of the eye (the retina), as seen upon ophthalmoscope examination.

Optically Aided Viewing

Viewing with a telescopic (binocular) or magnifying optic. Under certain circumstances, viewing with an optical aid can increase the hazard from a laser beam.

Optical Density (OD)

The OD is the measure of the laser radiation permitted to pass through a filter. Laser protective eyewear will always specify an OD for specific wavelengths of laser light.

Personal Protective Equipment (PPE)

Equipment worn to minimize exposure to laser radiation. The most common PPE is laser protective eyewear. Skin covering may be required for certain applications work around UV laser radiation.

Protective Housing

An enclosure that surrounds the laser or laser system and prevents access to laser radiation above the applicable MPE. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing limits access to other associated radiant energy emissions and to electrical hazards associated with components and terminals, and may enclose associated optics and a workstation.

Pulse Duration

The duration of a laser pulse, usually measured as the time interval between the half-power points on the leading and trailing edges of the pulse.

Pulse-repetition Frequency (PRF)

The number of pulses occurring per second, expressed in hertz.

Pulsed Laser

A laser which delivers its energy in the form of a single pulse or a train of pulses. In this standard, the duration of a pulse is less than 0.25 s.

Pupil

The variable aperture in the iris through which light travels to the interior of the eye

Q-switched Laser

A laser that emits short (~10-250 ns), high-power pulses by means of a Q-switch

Repetitive Pulse Laser

A laser with multiple pulses of radiant energy occurring in a sequence

Retinal Hazard Region

Optical radiation with wavelengths between 0.4 and 1.4 μm , where the principal hazard is usually to the retina.

Safety Latch

A mechanical device designed to require a conscious decision to override the latch to gain entry into a controlled area.

Secured Enclosure

An enclosure to which casual access is impeded by an appropriate means, e.g., a door secured by a magnetically or electrically operated lock or latch, or by fasteners that need a tool to remove.

Spectator

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

Specular Reflection

A mirror-like reflection. The specular reflection of the laser can be as hazardous as the primary laser beam

Standard Operating Procedure (SOP)

Formal written description of the safety and administrative procedures to be followed in performing a specific task/operation.

Threshold Limit (TL)

The TL is an expression of the “resistance factor” for beam penetration of a laser protective device (such as eyewear filters, protective windows, and barriers). The Threshold Limit (TL) of the protective device is generally expressed in $W \cdot cm^{-2}$ or $J \cdot cm^{-2}$. It is the maximum average irradiance or radiant exposure at a given beam diameter for which a laser protective device provides adequate beam resistance. Thus, laser exposures delivered on the protective device at or below the TL will limit beam penetration to levels at or below the applicable MPE.

Ultraviolet Radiation

Electromagnetic radiation with wavelengths between 0.18 and 0.40 μm (shorter than those of visible radiation)

Uncontrolled Area

An area where the occupancy and activity of those within is not subject to control and supervision for the purpose of protection from radiation hazards

Viewing Window

A visually transparent part of an enclosure that contains a laser process. It may be possible to observe the laser processes through the viewing windows.

Visible Light Transmission (VLT)

The percent of visible light transmitted through laser protective eyewear. The VLT of laser protective eyewear should be as high as possible to aid in viewing the work environment.

Visible Radiation (light)

The term is used to describe electromagnetic radiation which can be detected by the human eye. This term is used to describe wavelengths which lie in the range 0.4 to 0.7 μm . Derivative standards may legitimately use 0.38 – 0.78 μm for the visible radiation range.

Appendix B: USF Class 3B and 4 registration form

Laser owner name (PI) _____ Phone # _____

Department: _____ USF mail address _____

E-mail address: _____

Please provide the following for each class 3B and 4 laser

Laser Manufacturer _____ Model _____

Type of Laser _____

Serial Number from laser head _____

Max rated power: _____ Units: _____

Laser Class circle: 3B 4

Wavelengths (nm): _____ Room location: _____

Laser primary use (circle one): Research Medical Industrial

Current Status (circle one): In use Stored for later use stored for parts

Form completed by: _____ Date: _____

Phone number: _____

INSTRUCTIONS:

- ❖ Complete the form, and send to the Laser Safety Officer- Adam Weaver MDC35.
- ❖ E-mail to aweaver@usf.edu or Fax to 813-974-7091
- ❖ Call Adam 813-974-1194 with any questions or concerns.

Appendix C: Control Measures for Specific Laser Applications

CONTROL MEASURES FOR LASER POINTERS

Laser Pointers shall not exceed Class 3R, and are exempted from area posting requirements. Users must be aware of the potential hazards and follow safety procedures provided by the manufacturer.



When used responsibly for the intended purpose such as an aid in visual presentations, laser pointers are valuable tools that present little potential hazard. However, laser pointers have received a lot of attention in the media and have raised public concern. The safety concerns regarding the use of lasers are the potential optical hazards. These optical hazards may be exposures from momentary direct viewing with the potential side effects being glare, flash-blindness, after images and possible startle effects. Typically these side effects last on the order of several minutes up to a few hours.

Under no circumstances will visible laser beams be directed toward automobiles, aircraft, or other manned structures or vehicles, or otherwise disrupt critical tasks.

A laser pointer contains a small diode laser that emits an intense beam of light. Most laser pointers contain low to moderate powered lasers that do not pose a serious risk of eye injury unless intentionally misused. Some of the newer laser pointers, especially the green light pointers, present a significantly increased risk of eye injury.

Direct viewing of the laser beam may cause temporary flash blindness, headaches, afterimages or glare. Besides the risk of injury from the beam, the outrage from being exposed or loss of concentration may promote other hazards.

The following safety considerations should be observed when using laser pointers:

- Never look directly into the laser beam
- Never point a laser at a person
- Do not aim the laser at a highly reflective surface
- Only use laser pointers that have Laser Radiation labeling

CONTROL MEASURES FOR LASER LEVELS

Laser levels and other laser devices used in construction are typically Class 3A or 3R. These can produce spot blindness and other eye injuries, but are safe to use if you follow the laser safety precautions from the manufacturer, and observe basic laser safety practices:

- never stare into a laser beam.
- don't try to repair or disassemble a laser level.
- Read the instruction manual before you use a laser level.
- never point a laser level at vehicles, drivers, people, or pets.
- don't let children play with laser levels.
- always turn the laser level off when you're not using it. Leaving it on increases the risk of someone unintentionally staring into the laser beam.
- don't remove or deface any laser level labels.

- The laser light is very bright compared to ordinary light, enough to cause an automatic aversion response against the intense light (blinking to close the eyelid, turning the head to avoid the light, automatic constriction of the pupil). Prevent injury to the eye by avoiding intentionally overcoming this aversion response.
- Don't operate a laser level near flammable liquids, gasses, or dust.
- Don't aim the laser beam at shiny or reflective surfaces; they're not suitable for laser use.

CONTROL MEASURES FOR CONFOCAL MICROSCOPES

Laser scanning confocal microscopes are Class 1 laser systems that contain embedded Class 3B or Class 4 lasers. When the confocal microscope is used as intended, no control measures are necessary. If the protective housing is removed for alignment, maintenance or service activities, a temporary laser-controlled area shall be established and control measures appropriate to the class of the embedded laser shall be implemented.

Appendix D: Laser Classifications

Lasers classes are based on the capability of injuring personnel. The manufacturer is responsible for properly classifying lasers using US FDA regulations and ANSI Z136.1 (2014)

Human Aversion Response: Laser light is very bright compared to ordinary light, bright enough to cause an automatic aversion response against the intense light (blinking to close the eyelid, turning the head to avoid the light, automatic constriction of the pupil). The human aversion response of 0.25 seconds can be used to evaluate the potential for injury from visible laser light, such as Class 1, 2 and 3A lasers. Prevent injury to the eye by avoiding intentionally overcoming this aversion response. Note that Class 3B and Class 4 lasers are capable of causing injury before the aversion response has time to protect the eye; Class 3A and 3R have the potential in certain cases to cause injury before the aversion response can protect the eye.

Summary of Laser Classes and Hazards

Class 1

These are low-power lasers and laser systems that cannot emit radiation levels greater than the maximum permissible exposure (MPE). Class 1 lasers and laser systems are incapable of causing eye injury under normal operating conditions. This class may include lasers of a higher class whose beam are confined within a suitable enclosure so that access to laser radiation is physically prevented.

Class 1M

Class 1M lasers produce large-diameter beams, or beams that are divergent. The MPE for a Class 1M laser cannot normally be exceeded unless focusing or imaging optics are used to narrow down the beam. If the beam is refocused, the hazard of Class 1M laser may be increased and the product class may be changed.

Class 2

A Class 2 laser emits in the visible region. It is presumed that the human blink reflex (<0.25 seconds) will be sufficient to prevent damaging exposure, although prolonged viewing may be dangerous. Class 2 lasers are limited to 1 mW when operating in the continuous wave mode, or more if the emission time is less than 0.25 seconds.

Class 2M

A Class 2M laser emits in the visible portion of the spectrum in the form of a large diameter or divergent beam. It is presumed that the human blink reflex will be sufficient to prevent damaging exposure, but if the beam is focused down, damaging levels of radiation may be reached and may lead to a reclassification of the laser.

Class 3R (old 3a)

A Class 3R laser is potentially hazardous under some direct and specular reflection viewing condition if the eye is appropriately focused and stable, but the probability of an actual injury is small. This laser will not pose either a fire hazard or diffused-reflection hazard. Class 3R visible lasers (0.4 to 0.7 μm) are limited to 5 mW when operating in continuous wave mode. For other wavelengths and pulse lasers, other limits apply.

Class 3B

Class 3B lasers are capable of causing eye damage from short-duration (< 0.25s) viewing of the direct or specularly-reflected beam. Diffuse reflections from these lasers are generally not hazardous, except for intentional staring at distances close to the diffuser.

Class 4

Lasers in this class are high powered and capable of causing severe eye damage with short-duration exposure to the direct, specularly-reflected, or diffusely-reflected beam. They are also capable of producing severe skin damage. Flammable or combustible materials may ignite if exposed to the direct beam. Accidental exposure to high powered Class 4 lasers may result in serious injury or death.

Appendix E: Alignment Procedures Guidelines

MORE LASER ACCIDENTS OCCUR DURING BEAM ALIGNMENT THAN ANY OTHER LASER MANIPULATION. USE THE FOLLOWING TECHNIQUES TO PREVENT ACCIDENTS.

- ✓ Notify all lab personnel in room that laser alignment will be on-going
- ✓ Exclude unnecessary personnel from the laser controlled area during alignment
- ✓ Perform alignment at the lowest possible power level
- ✓ Use low-power visible lasers for path simulation of high-power visible or invisible lasers, when possible
- ✓ Use a temporary beam attenuator over the beam aperture to reduce the level of laser radiation below the MPE, when possible
- ✓ Wear laser safety eyewear during alignment - Laser alignment eyewear provides less protection than laser protective eyewear designed for full power operation, but alignment eyewear balances protection with ability to view the laser beam. Alignment eyewear may be used when operating the primary laser at low power, or when using a low power visible laser specifically for alignment.
- ✓ Use beam display devices (image converter viewers or phosphor cards) to locate beams when aligning invisible lasers
- ✓ Use shutters or beam blocks to block high-power beams at their source except when needed during the alignment procedure
- ✓ Use beam blocks to block high-power beams downstream of the optics being aligned
- ✓ Use beam blocks or protective barriers when alignment beams could stray into areas with uninvolved personnel
- ✓ Place beam blocks behind optics such as turning mirrors to terminate beams that may miss the mirrors during alignment
- ✓ Locate and block all stray reflections before proceeding to the next optical component or section
- ✓ Ensure that all beams and reflections are terminated before resuming high-power operation

Appendix F: PI Laser Checklist

Use this checklist to evaluate the laser safety program in your lab.

This checklist is intended for Class 3B and Class 4 laser users. Note that not all safety items on this checklist will apply to your laser safety program.

PI: **Auditor:** **Audit Date:**

Building/Room

Lasers in USE in lab Manufacturer(s) - Model(s) **Laser Class: 3B / 4 / other:**

Class 3b and/or Class 4 lasers are registered with USF LSO: Y / N

Documents and Security

Each user has completed USF online laser safety training	Yes / No
Each user has received laser-specific training	Yes / No
Paper SOP's available for all Class 3B and 4 lasers	Yes / No
Alignment procedures/type of alignment laser	HeNe / Diode / IR / other:
Access door is posted with appropriate laser HAZARD sign	Yes / No

Engineering and Administrative Controls

Use the following to ensure the laser beams (direct and reflected beams) are not a hazard to persons sitting or standing, not at eye-level of workers at workstations, or exiting windows or doors

Beam path	Totally open / complete enclosed / combination
Beam path enclosed - method	Tubes / perimeter guards / panels / Class 1 product / fiber
Beam blocks	Secured / loose
Non-essential reflective materials out of beam paths and surroundings (general housekeeping in the NHZ)	Yes / No
Lasers & optics secured to table	Yes / No
Collecting optics used in room with potential to magnify laser light (circle applicable)	Microscopes / binoculars / telescopes / NA

Appendix G: USF class 3B and 4 Laser user template Laser System Standard Operating Procedure (SOP) Template

All Principal Investigators are **required** to write standard operating procedures (SOP) for all laser operations involving Class 3B and 4 lasers detailing alignment, operation, and maintenance procedures for each laser. The SOP must be available to all laser users in the laboratory. This SOP shall address specific safety considerations during beam alignment, normal operations, servicing and any non-beam hazards that might exist. The key to any SOP is to keep it as simple as possible so that it can be used on a routine basis.

This Standard Operating Procedure (SOP) was developed as a standard for good safety practices while utilizing the laser or laser system. This SOP shall address specific safety considerations during beam alignment, normal operations, servicing and any non-beam hazards that might exist. This SOP does not take the place of specific laser safety training associated with the laser. Documentation of laser safety training should be kept with the SOP.

Instructions:

- *PI shall use this template to create a standard operating procedure for each Class 3B or Class 4 laser.*
- *The PI shall train all Laser Users on this procedure and ensure it is followed each time the laser is used.*
- *Keep this paper SOP in a common location readily available to the PI and Laser User.*
- *This SOP should always be available for review upon request of the Laser Safety Officer.*
- *For specifications or operating conditions that frequently change, list anticipated ranges of specifications or operational settings.*

This Laser Standard Operating Procedure has been written to aid with the safe use of the laser identified below. Laser Supervisors and Laser Users must follow this procedure for each laser use.

LASER SAFETY CONTACTS

Laser PI:		Phone:		Mobile:	
Primary Laser User:		Phone:		Mobile:	
Laser Safety Officer:	Adam Weaver	Phone::	813-974-1194	Mobile:	727-479-4740

1. LASER DESCRIPTION

Laser Type:		Laser Location	
Manufacturer:		Department:	
Model:		Building:	
Class:	<input type="checkbox"/> 3B <input type="checkbox"/> 4	Room Number:	

Laser Output	Wavelength(s) or Wavelength Range (nm)	Power (W)	Pulse Energy (J)	Pulse Duration (sec)	Pulse Frequency (Hz)
<input type="checkbox"/> Continuous <input type="checkbox"/> Pulsed					

Brief Description of Laser Use (specific to the lab):

2. SETUP, ALIGNMENT AND OPERATING PROCEDURES

A. Alignment/Setup

(Please indicate who will be responsible for performing these procedures and include specific beam alignment/visualization aids to be used as well as PPE.)

B. Start-up and Operation

(List the basic sequential events that describe the complete operation, including when to don laser eyewear, etc. The procedures shall be written for the benefit of the Laser User who must read and understand them to perform the operation safely.)

Laser Hazard Control Measures		
Check if applicable	Control	Comments
<input type="checkbox"/>	Entryway (door) interlocks	
<input type="checkbox"/>	Laser protective housing interlocks	
<input type="checkbox"/>	Emergency stop/panic button	
<input type="checkbox"/>	Master switch (operated by key or computer password)	
<input type="checkbox"/>	Beam stops/attenuators	
<input type="checkbox"/>	Beam path enclosure (e.g., light pipe)	
<input type="checkbox"/>	Protective barriers	
<input type="checkbox"/>	Warning signs	
<input type="checkbox"/>	Warning lights	

<input type="checkbox"/>	Other (specify):	
--------------------------	------------------	--

C. *Shutdown*
 (Describe normal and emergency shutdown procedures)

3. PERSONAL PROTECTIVE EQUIPMENT

Laser Protective Eyewear

<i>WEAR THIS EYEWEAR</i>		
<i>Eyewear Manufacturer</i>	<i>Protected Wavelength(s)</i>	<i>Optical Density (OD)</i>

Other Protective Equipment

Describe other protective equipment used. This might include the use of lab coats and/or sunscreen for UV laser use. Other items to describe here include laser rated barriers, curtains, window filters, etc.

4. NON-BEAM HAZARDS OF THIS SYSTEM (CHECK ALL THAT APPLY)

Check all non-beam hazards that apply and provide a brief description of the control measure(s) implemented to control the hazard.

Chemical (dyes, solvents, etc.); attach applicable Safety Data Sheet (SDS)

Biological agents

Electrical (high voltage, large current, capacitors, etc.)

Laser Generated Air Contaminants

Compressed gases or cryogenic liquids

Fire/ignition source

Plasma/blue light exposure

Other (specify):

Laser User Review:

I have read and understand this procedure and have been trained on implementing its contents.

Name (Printed)	Signature	Date
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

INSTRUCTIONS:

- ❖ Send a copy to the USF Laser Safety Officer- Adam Weaver MDC35.
- ❖ E-mail to aweaver@usf.edu or Fax to 813-974-7091
- ❖ Call Adam 813-974-1194 with any questions or concerns

APPENDIX H:

USF Laser Safety Committee Duties and Responsibilities

The USF Laser Safety Committee shall consist of faculty and staff who by their knowledge and experience are qualified to make judgments and recommend policy in the area of laser safety. Committee members shall be appointed by the Senior Vice-President for Research & Innovation and the ties in consultation with the various deans, directors, and department heads.

The USF Laser Safety Committee should meet every six months or more often, if there are pending issues for committee action, or at the request of any member. USF Laser Safety Committee meetings can be held in a room, via E-mail, and/or a conference call.

Attendance or participation by at least 50% of the members is required for a quorum. The chairperson or the Laser Safety Officer or their duly authorized representatives, are authorized to act as agents of the Committee between meetings to ensure the timely processing of applications and to conduct other business. Any action taken by the chairperson or Laser Safety Officer on behalf of the Committee shall be reported at the next meeting.

The duties and responsibilities of the Committee are:

- Assume responsibility for defining an environment that promotes the safe use of lasers and laser systems.
- Prescribe procedures, conditions, requirements, and restrictions as necessary to protect University employees, students, visitors, the public, and the environment from hazards associated with lasers and laser systems. Such policies and procedures, conditions, restrictions, and requirements shall be consistent with federal or state regulations or recognized consensus standards.
- Review, approve, or disapprove applications to acquire, fabricate, use, or transfer Class 3B and 4 lasers or laser systems at USF facilities and operations. Committee approval must be obtained before any project involving Class 3B or 4 lasers or laser systems is initiated. Prepare and disseminate information on laser safety and the policies, rules, procedures, and practices related thereto, for the use and guidance of staff and students.
- Recommend to department and school administration appropriate physical improvements necessary to raise existing facilities to a level consistent with current laser safety standards.
- Keep a written record of the activities, actions, decisions, recommendations, transactions, communications, and reports.

Actions of the Committee may be appealed to the Senior Vice-President for Research & Innovation with the knowledge and consent of the department head or director of the unit involved.

Approved by: _____