

# LASER SAFETY PLAN

THE UNIVERSITY OF TEXAS AT SAN ANTONIO

OFFICE OF RESEARCH INTEGRITY

LABORATORY SAFETY DIVISION

## REVIEW PAGE

This version of the manual has been reviewed for regulatory compliance and best management practices by the listed individuals and committees and is hereby adopted for use and compliance by all employees at the University of Texas at San Antonio owned or operated facilities.

NAME	TITLE	DATE
Amanda Haley	Interim Laboratory Safety Manager and LSO	10-31-2018
Michelle Stevenson	Associate Vice President of Research Administration	11-2-2018
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## COMMITTEE

COMMITTEE	REVIEW DATE	APPROVAL DATE
Radiation and Laser Safety Committee	10-18-2018	10-23-2018

Review: October 3, 2018

Replaces: April 6, 2013

Review Frequency: Annual

The October 3, 2018 version replaces the April 6, 2013 version.

Changes to the plan are highlighted in "gray" and summarized below.

SECTION	SUMMARY OF CHANGE
Emergency Contacts	Laser Safety Officer contact number updated.
IV B	Requirement for consultants to be registered with the state.
V	Laser class overview added, Texas dshs web address added.
Appendix A	Appendix A added

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## EMERGENCY CONTACTS

<b>ROUTINE OFFICE HOURS (8am – 5pm)</b>	
Laser Safety Officer	210-458-8515
Radiation Safety Officer	210-458-5807
Radiation and Laser Safety Personnel	210-458-5807
EHSRM Office	210-458-5250
<b>AFTER HOURS (including weekends)</b>	
UTSA Police	210-458-4911 (cell or outside phone) x4911 (from a campus phone)
<b>LIFE THREATENING EMERGENCIES (any time)</b>	
UTSA Police	210-458-4911 (cell or outside phone) x4911 (from a campus phone)

### ROUTINE CONTACTS

In case of incidents involving laser exposure, all personnel are required to notify the Laser Safety Officer immediately at 210-458-8515.

After 5:00 pm and on weekends, UTSA Police will assist in contacting Laser Safety Personnel.

## I. OVERVIEW

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This plan provides guidelines for protection against all classes of laser radiation and intense-pulsed light (IPL) device hazards based on regulations established by the state and the federal governments. This plan includes the responsibilities of those in the various roles involved with lasers. It provides individuals using lasers information on laser hazards, laser-related policies and procedures, recommendations for the safe use of lasers, and information on laser safety training. It has been designed to provide the basis for safe laser use in the research and teaching environment.

## II. SCOPE

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This plan applies to all persons at UTSA who receive, possess, acquire, transfer, or use lasers that emit or may emit laser radiation. The plan applies to all facilities owned, operated or leased by UTSA where lasers are used or stored, to all personnel, whether from inside or outside UTSA, who work on these premises, and all laser equipment owned or leased by UTSA or used within the premises of UTSA.

This plan applies to lasers that operate at wavelengths between 180 nanometers (nm) and 1 millimeter (mm).

This plan also applies to intense pulsed light (IPL) devices. These devices are Class 2 or Class 3 surgical devices certified as complying with the design, labeling, and manufacturing standards of the United States Food and Drug Administration (FDA). They differ from lasers in that they operate over specific parts of or the entire spectrum from 500 to 1200 nm.

All persons at UTSA authorized to use Class 3b and Class 4 lasers are subject to the following sections of the Texas Administrative Code (TAC): §289.203, .204, .205, .231, and .301. The American National Standard Institute standard Safe Use of Lasers, ANSI Z136.1 and standard Safe Use of Lasers in Research, Development, or Testing ANSI Z136.8 contain safe practice details. ANSI Z136.1 is referenced in the TAC laser sections.

### **Prohibitions.**

UTSA may prohibit the use of lasers and IPL devices that pose significant threat or endanger occupational or public health and safety, in accordance with state regulations.

Individuals shall not be intentionally exposed to laser and IPL radiation without first obtaining all appropriate permissions from the Radiation and Laser Safety Committee (R&LSC), the Institutional Review Board (IRB) and the Texas Department of State Health Services (TXDSHS). Contact the Laser Safety Officer (LSO) well in advance of planned work to ensure all university, state and federal requirements are met prior to beginning such a project.

## III. PERIODIC REVIEW

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The contents of this plan will be reviewed whenever relevant sections of the TAC on the use of lasers are changed and whenever internal policy decisions mandate a review and annually by the Laboratory Safety Division and any pertinent committees.

## **IV. RESPONSIBILITIES**

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This section was developed to inform supervisors and operators of their roles and responsibilities to assist in providing a safe laser environment at UTSA.

### **A. RESPONSIBILITY AND AUTHORITY OF THE LASER SAFETY OFFICER**

1. The LSO will work with the individual PI to ensure the safety standards are adequately met at the given laser laboratory. The LSO has the authority to monitor and enforce the control of laser hazards.
2. The LSO will provide consultative services on laser hazard evaluation and controls, and on personnel training programs.
3. Training shall be provided to each employee and student planning to operate a Class 3b or 4 laser or laser system or work in an area where such a laser is in operation. A comprehensive laser safety training program is available from EHSRM. Additional laser-specific training programs are encouraged. The R&LSC should be informed of the content of these alternative programs. The EHSRM training course must be completed before any individual begins work with a laser or in an area where a laser used. The Laser Safety Course has course number SA465 and is available online at the Training and Development Department's website.
4. The LSO will register all class 3b and 4 lasers with TXDSHS for UTSA and maintain appropriate records as required for registration.

### **B. RESPONSIBILITY OF THE PRINCIPAL INVESTIGATOR**

1. The PI shall know the educational and training requirements, the potential laser hazards and associated control measures, and all operating procedures pertaining to laser safety for lasers and laser systems under the PI's control. Generally the PI is the faculty member in charge of a laser facility/laboratory.
2. Prior to ordering or acquiring a class 3b or 4 laser the PI shall notify the LSO and provide any requested information to assist in the registration of the laser.
3. The PI shall ensure that he/she, as well as all laser users under his/her control, are trained and have taken formal UTSA Laser Safety Training, SA465.
4. The PI shall determine which students and employees are authorized to operate a laser under his/her control. The PI may grant temporary permission to use the laser, if system-specific laser safety training and documentation are provided to the R&LSC before use and approval gained.
5. The PI shall notify the LSO immediately of known or suspected laser-related accidents and injuries. The PI shall ensure that their departmental business office is promptly notified. If necessary, the PI will assist in obtaining appropriate medical attention for any employee or student involved in the laser accident. The PI shall cooperate with the LSO and/or R&LSC during the course of their investigation and implement recommendations to prevent a recurrence. A written incident report of any actual injury shall be prepared by the PI and submitted to the LSO as soon as possible as UTSA is required to file a report with the state within 30 days.

6. The PI shall not permit operation of a new, modified or manufactured class 3b or 4 laser under his/her authority without prior approval of the R&LSC. Additionally location is part of the approval process and NO LASER MAY BE RELOCATED, even within the same laboratory, without prior permission of the R&LSC.
7. The PI shall assure that plans for laser installations or modifications of installations are submitted to the R&LSC for approval. Any outside consultants MUST have a Laser Demonstrator Registration according to TAC 289.301 (g) (3) in order to do any laser demonstrations. The LSO will act as a consultant, in conjunction with Facilities Planning, for the installation of new laser facilities.
8. For Class 3b and 4 laser systems, the PI shall ensure standard operating procedures (SOPs) are developed and provided in order to prevent the operation of a laser if exposure to employees, students, visitors, or the general public could exceed the maximum permissible exposure (MPE). Standard Operating Procedures (SOPs) are necessary for alignment, maintenance, service and emergency response.
9. Prior to the disposal or transfer of any class 3b or 4 laser the PI must contact the LSO. This includes sending lasers to the Surplus Department. UTSA is required by regulation to maintain information on final disposition of all registered lasers.

### **C. RESPONSIBILITY OF EMPLOYEES AND STUDENTS WORKING WITH OR NEAR LASERS**

1. An employee or student shall not operate a class 3b or 4 laser system unless authorized to do so by the PI for that laser. The PI may give system specific laser safety training and grant temporary permission to use the laser, if the individual is certified as having completed UTSA Laser Safety Training by the Laboratory Safety Division and informing the R&LSC.
2. All employees and students shall comply with the safety rules and regulations prescribed by the PI, LSO, and R&LSC. Employees and students shall know the operating procedures applicable to their work.
3. All injuries and accidents involving lasers and laser systems must be reported to the PI and the LSO. However, the treatment of injured personnel and the preservation of property shall be the first priority.

### **D. RESPONSIBILITY AND AUTHORITY OF THE RADIATION AND LASER SAFETY COMMITTEE (R&LSC)**

1. The UTSA R&LSC 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 and radiation safety. Committee members shall be appointed by the Vice President of Research, Economic Development and Knowledge Enterprise (VPREDKE) upon recommendation of the Committee on Committees in consultation with the various deans, directors, and department heads.
2. The committee shall establish and maintain policies, procedures, and guidance for the control of laser hazards.
3. Approval of a laser or laser system for operation will be given only if the R&LSC is satisfied that the laser hazard control measures are adequate. These include SOPs, engineering controls for the laser, engineering controls for the laboratory or area, and administrative and procedural controls for the laser facility/laboratory. SOPs for alignment, maintenance and/or service, and emergency response shall be provided as necessary.

4. The committee will review all applicable new or revised laser safety standards.
5. The R&LSC and the LSO have the authority to suspend, restrict, or terminate the operation of a laser project if it is deemed that the laser hazard controls are inadequate.

#### **E. RESPONSIBILITY OF THE UTSA PURCHASING DEPARTMENT**

1. The UTSA Purchasing Department will inform the LSO of all orders for lasers and laser systems. Notification should be in the form of a copy of the Purchasing Requisition. The LSO will contact the PI to determine if the appropriate laser safety controls are in place, and to help remedy any problems or deficiencies.

#### **F. RESPONSIBILITY OF THE UTSA SURPLUS DEPARTMENT**

The UTSA Surplus Department will inform the LSO of all requests submitted for pickup of lasers. The LSO will determine the disposition of any surplus lasers.



## V. INTRODUCTION TO LASER SAFETY

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### A. LASER CLASSES

1. All lasers sold in the U.S. are required to have a label listing the class of the laser (Fig 1. Example of a laser identification label)



Fig 1. Laser identification label

2. Class 1 Lasers
  - a. Incapable of producing damaging radiation levels during operation.
  - b. Example: Completely enclosed machine with a higher powered laser inside.
3. Class 1M Lasers
  - a. Incapable of producing damaging radiation levels during operation unless the beam is viewed with an optical instrument (e.g. loupe or telescope).
  - b. Example: Fiber optic communication systems.
4. Class 2 (Low Power)
  - a. Output below 1mW.
  - b. Emit visible light only (400 – 700nm).
  - c. Example: Barcode scanners
5. Class 2M
  - a. Output upper limit is 1mW.
  - b. Emit visible light only (400 – 700nm).
  - c. Potential hazard if viewed with an optical aid.
  - d. Example: Leveling instruments.
6. Class 3R
  - a. Potentially hazardous under some direct and specular reflection.

b. Does not pose a diffuse-reflection or fire hazard.

c. Example: Laser pointer

#### 7. Class 3b

a. Operate between 5mW and 500mW

b. Normally does not pose a diffuse viewing or fire hazard. However, they can heat skin and materials.

c. Hazardous under direct and specular reflection viewing.

d. Example: therapeutic medical lasers.

#### 8. Class 4

a. Output greater than 500mW.

b. Hazardous to eyes and skin from direct viewing, diffuse and scattered reflections.

c. Present a fire hazard if directed at combustible material.

d. Can produce air contaminants and plasma radiation.

e. Example: Surgical lasers.

## B. LASER HAZARDS

The foremost hazard lasers pose is to the eyes. Direct or indirect exposure to lasers can lead to irreparable damage to parts of the eye and permanent partial or complete loss of vision. Depending on the wavelength of the laser light, your cornea, lens, or retina may absorb the light. When too much absorption occurs, the cells are burned, leading to damage.

- High-power lasers usually have large power supplies designed to deliver large currents, often at high voltages. Accidents during troubleshooting can be fatal. **NEVER** work on power supplies. This work should be done by a certified technician or manufacturer's representative.
- High-power lasers can ignite laboratory equipment, leading to fire and smoke damage to the laboratory.
- Direct exposure to the beam may cause skin damage. Effects on the skin are both photochemical and thermal depending on the wavelength of the laser light. Symptoms range from mild reddening (erythema) to blistering and charring. Additionally, there are possible carcinogenic effects.
- Excimer lasers make use of reactive gases requiring special safety precautions and procedures to prevent exposure.
- The severity of effects of laser hazards depend on the type of laser, the wavelength, pulse energy (or power for a continuous wave laser), pulse duration (or exposure duration for a continuous wave laser), and the type of application.
- Non-beam hazards include fumes, compressed gases, cryogenic materials, noise, electrical hazards, fire, explosion, and collateral radiation.

- Hazards of a class 1, 2, or 3R laser are much less significant than those of a class 3b or 4 laser. The blink reflex or normal human aversion reflex is considered sufficient to protect against lower powered laser hazards. Even for these low power class lasers direct exposure of the eye to the output beam can be damaging. Laser beams viewed through collecting optics can cause eye damage. In addition, many of these lasers, regardless of class, have high-voltage power supplies that can be hazardous.

### **C. EXPOSURE LIMITS**

1. Refer to the American National Standard for Safe Use of Lasers, ANSI Z136.1, for hazard analysis of several different laser types. This ANSI standard is available for checkout from the LSO.
2. Refer to APPENDIX B for information on common types of lasers and check the laser identification label. If the data you are looking for is not there, contact the Laboratory Safety Office.

### **D. PRECAUTIONS**

1. Follow the safety procedures for the laboratory and the laser being used.
2. Wear R&LSC and ANSI Z136.1 approved laser safety goggles with the proper optical density for the specific wavelength(es) of the laser. Even with goggles, direct exposure to a laser beam is hazardous. Laser safety goggles are meant to protect for short exposures.
3. One simple rule is to keep the beam horizontal and at waist level so the eyes of personnel standing in the laboratory are well above the beam plane. Keep reflective surfaces out of the beam line as specular reflections present a hazard. With higher powered lasers even apparently matte surfaces may cause a specular reflection.
4. Question practices that appear unsafe. Are they necessary or outdated? Can the same function be performed in a manner that is less dangerous? Can the unsafe practices be replaced by some other safer practice? Are work practices designed for expediency at the expense of safety?

### **E. OPERATING PROCEDURES**

1. Operating procedures must be developed for each class 3b or 4 laser and any IPL device. They are recommended for all other lasers. The LSO is available to provide assistance in developing operating procedures.
2. Procedures at UTSA are based on Texas regulations and many of the guidelines developed by professional organizations such as ANSI. The Texas regulations may be downloaded from the TXDSHS website ([www.dshs.texas.gov](http://www.dshs.texas.gov)). ANSI standards must be purchased, but the LSO maintains copies.

## **VI. CONTROL MEASURES**

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### **A. INTRODUCTION**

Control measures for Class 3b and 4 lasers are designed to reduce the possibility of eye and skin exposure to hazardous levels of radiation and to other hazards associated with the laser systems. The major causes of laser accidents in the laboratory are:

1. Eye exposure during alignment.
2. Misaligned optics and upwardly directed beams.
3. Available eye protection not used.
4. Equipment malfunction.
5. Improper methods of handling high-voltage circuits.
6. Intentional exposure of unprotected personnel.
7. Operators unfamiliar with laser equipment.
8. Lack of protection from ancillary hazards.
9. Improper restoration of equipment following service.
10. Eyewear worn not appropriate for laser in use.
11. Failure to follow SOPs.

Laser control measures are classified as engineering control measures and administrative and procedural control measures. Engineering controls are those that are incorporated into the laser system and the laser laboratory. Administrative and procedural controls are methods or instructions which specify rules and/or work practices to supplement engineering controls and may require use of personal protective equipment. An example of an engineering control measure would be a laser beam stop, and an example of an administrative and procedural control measure would be the SOPs. When feasible, engineering controls are always the preferred method to provide for safety in a laser laboratory.

Control measures are designed to ensure skin and eye exposures do not exceed the applicable MPE limit. The MPE defines the maximum safe exposure without hazardous effect or adverse biological changes in the eye or skin. The MPE depends upon the wavelength and exposure duration.

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

### **B. ENGINEERING CONTROLS**

Engineering controls for Class 3b and 4 lasers as required by regulation are listed below. All Class 3b and 4 lasers at UTSA are covered by this policy, and should have the listed design features unless otherwise approved by the LSO and R&LSC.

If the system is purchased in the United States, the system has as part of the design features the controls stated below. This is often indicated on the laser by a “statement of certification”.

1. A protective housing shall be provided for each laser system. The protective housing shall be interlocked such that removal of the protective housing will prevent exposure to laser radiation. Interlocks shall not be defeated or overridden during normal operation of the laser.
2. Service access panels that allow access to the beam during operation shall be interlocked and have an appropriate warning label.
3. A Class 3b or class 4 laser shall have a key-controlled or computer-actuated master switch. The authority for access to the key shall be vested in the PI.
4. All viewing portals, display screens, and collecting optics shall be designed to prevent exposure to the laser beam above the applicable MPE for all conditions of operation and maintenance.
5. A laser control area shall be designated for all unenclosed beam paths. The laser control area is defined as the area where laser radiation is in excess of the MPE. The appropriate control measures must be implemented in the laser controlled area.
6. A Class 3b laser should be provided with a remote interlock connector. A Class 4 laser shall have a remote interlock connector. The remote interlock connector will decrease the laser beam power to safe levels when activated. Exceptions must be approved by the LSO and R&LSC.
7. The R&LSC will follow the recommendations and requirements as set forth by ANSI Z136.1 and ANSI Z136.8 in regards to interlocks for class 3b and 4 lasers. The R&LSC and/or the LSO have the authority to require more stringent entry controls based on a case by case analysis.
8. A Class 3b laser should have a permanent beam stop in place. A Class 4 laser shall have a permanent beam stop in place.
9. An alarm (for example, an audible sound such as a bell or chime), a warning light (visible through protective eyewear), or a verbal “countdown” command should be used at start-up of a Class 3b laser, and shall be used with Class 4 lasers. For Class 4 laser systems, the warning should allow sufficient time to take appropriate actions to avoid exposure to the laser beam.
10. Whenever possible, Class 4 lasers should be operated and fired from a remote location.

### **C. ADMINISTRATIVE AND PROCEDURAL CONTROLS**

1. Approval of the R&LSC is required for each laser laboratory. The application should be filed for approval before work begins. The application is available at the ORI Laboratory Safety website in the Radiation/Laser section.
2. Standard written operating procedures with safety controls, shall be provided to all laser users and be readily available for operation of the laser system. Refer to the laser application for a guide to assist in the development of SOPs. The instructions shall include clear warnings and precautions to avoid possible exposure to laser and collateral radiation in excess of the MPE. Operating procedures are to be maintained for inspection for the duration of the life of a laser.

3. Each laser operator shall have the education and training level commensurate with degree of hazard and responsibility.
4. All personnel using the laser shall be listed on the application submitted by the PI.
5. Alignment procedures shall be developed to ensure that eye exposure to the primary beam or to a diffuse or specular reflection does not exceed the MPE.
6. The laser laboratory shall be designed in such a way to limit spectator access to the laser controlled area.
7. Service personnel must comply with appropriate control procedures for the laser system and have education and training commensurate with the laser system.
8. Proper eye protection devices, specifically designed for the laser radiation, shall be worn when engineering or other administrative and procedural controls are inadequate to eliminate exposures above the MPE.

#### **D. CLASS 3B AND 4 LASER CONTROL AREA**

1. The area designated as the control area for Class 3b laser facilities shall have the following adequate control measures:
  - a. Operation only by qualified and authorized personnel.
  - b. Appropriate warning signs at all entryways and within the area.
  - c. Supervision by an authorized PI.
  - d. Limited spectator access. Visitors must be approved by the PI.
  - e. Appropriate beam stops for terminating potentially dangerous beams.
  - f. Only diffuse-reflective surfaces on non-optical structures in or near the beam path.
  - g. Appropriate eye protection for all personnel within the area.
  - h. Laser beam positioned well above or below eye level.
  - i. All windows, doorways, and open portals covered to prevent the laser radiation above the applicable MPE outside the laser facility.
  - j. Secured storage of laser equipment.
2. In addition to the above control measures for Class 3b laser facilities, the controlled area for Class 4 laser facilities (Figure 2) **shall** have the following control measures:
  - a. All entryway controls designed to allow rapid egress.
  - b. A "Panic Button" shall be clearly marked and readily accessible to the laser personnel. When activated, the "Panic Button" will reduce the output power of the laser to levels below the MPE. The following are acceptable examples of "Panic Buttons".
    - i. Key switches to deactivate the laser.
    - ii. Master switch on power source to turn off power.

- iii. Red mushroom-type button on control panel or other readily accessible location within the area.
3. Limited Access Entryway. The PI shall implement one of the following mechanisms to protect personnel. The LSO will be available for consultative services.
- a. Non-Defeatable (non-override) Entryway Safety Controls
    - i. Non-defeatable entryway controls will reduce the output power of the laser to levels below the MPE when the door is opened unexpectedly.
  - b. Defeatable Entryway Safety Controls
    - i. Defeatable entryway controls, with an override for safety latches and/or interlocks, may be used if it is clearly evident that there is no laser radiation hazard at the point of entry. Only adequately trained and authorized personnel may operate the overrides to enter the facility.
  - c. Procedural Entryway Safety Controls
    - i. All authorized personnel shall be trained, and proper personal protective equipment (PPE) shall be available at entry.
    - ii. A secondary barrier (laser curtain) shall be used to block the laser radiation at the entryway, screening the entrance from the entirety of the room.
    - iii. At the entryway there should be a visible or audible indication that the laser is in operation.

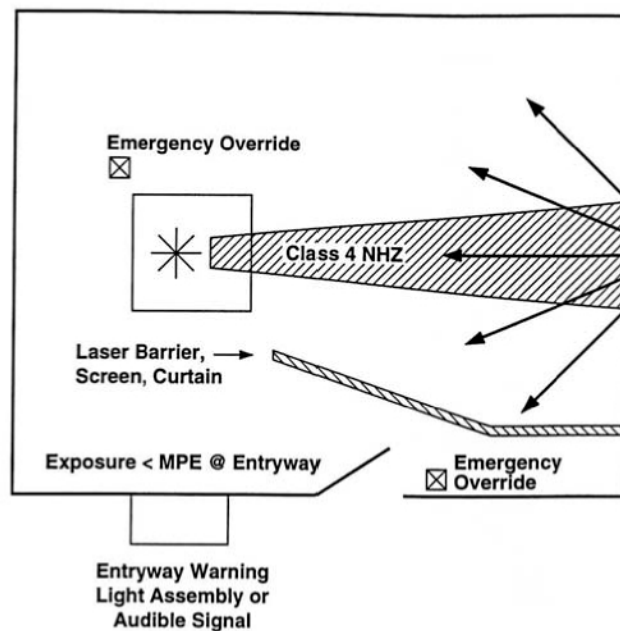


Fig.2 Class 4 Laser controlled area

## E. EQUIPMENT LABELS

All lasers (except Class 1) shall have appropriate warning labels with the laser sunburst logo and the appropriate cautionary statement (Figure 1). The labels shall be affixed to both the control panel and the laser housing. Ancillary hazards shall also be appropriately labeled.

## F. AREA POSTING SIGNS

Areas that contain Class 2 or 3a laser systems should be posted with appropriate area postings as described in Figure 3. Areas which contain Class 3b or 4 laser systems shall be posted with appropriate area postings as described in Figure 4. In addition, the laser-controlled area should be indicated with the appropriate warning sign.

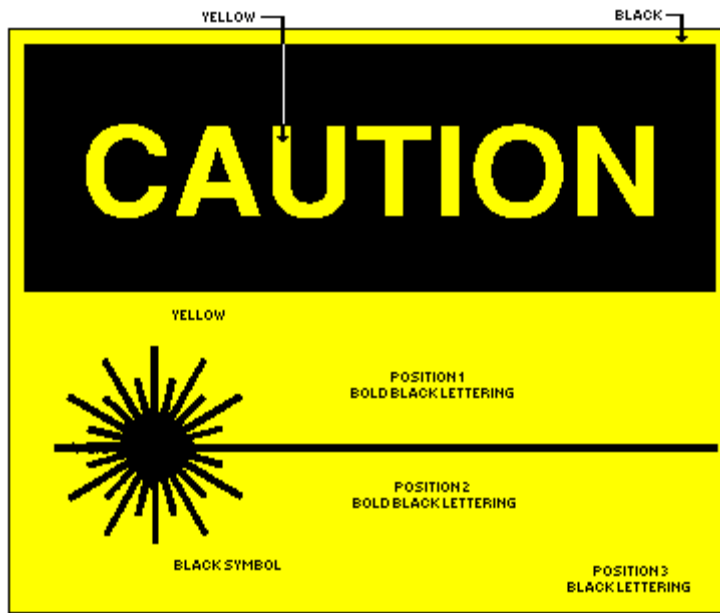


Fig 3. Area posting for Class 2 and 3R lasers ([www.osha.gov](http://www.osha.gov))



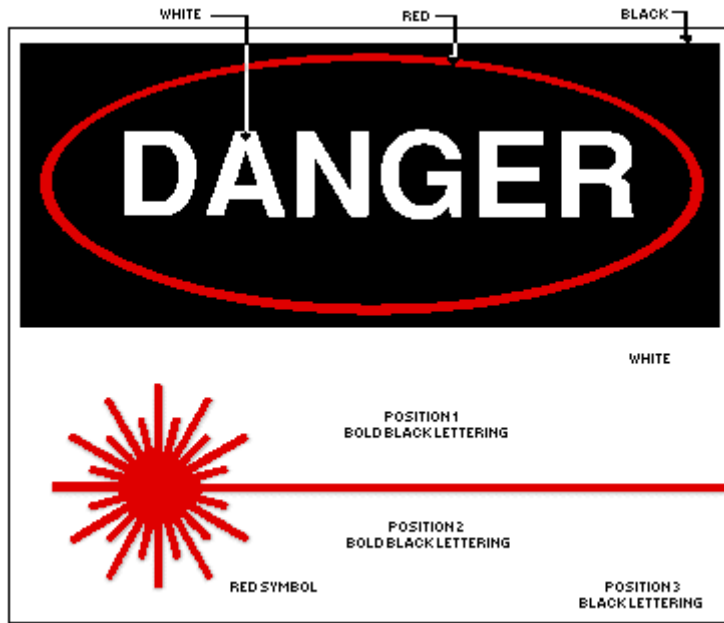


Fig 4. Area posting for Class 3b and 4 lasers ([www.osha.gov](http://www.osha.gov))

## APPENDIX A – DEFINITIONS OF LASER TERMS

**ABSORB** – To transform radiant energy into a different form, with a resultant rise in temperature.

**ABSORPTION** - Transformation of radiant energy to a different form of energy by the interaction of matter, depending on temperature and wavelength.

**ACCESSIBLE EMISSION LEVEL** - The magnitude of accessible laser (or collateral) radiation of a specific wavelength or emission duration at a particular point as measured by appropriate methods and devices. Also means radiation to which human access is possible in accordance with the definitions of the laser's hazard classification.

**Accessible Emission Level** - The magnitude of accessible laser (or collateral) radiation of a specific wavelength or emission duration at a particular point as measured by appropriate methods and devices. Also means radiation to which human access is possible in accordance with the definitions of the laser's hazard classification.

**Accessible Emission Limit (AEL)** - The maximum accessible emission level permitted within a particular class. In ANSI Z 136.1, AEL is determined as the product of accessible emission Maximum Permissible Exposure limit (MPE) and the area of the limiting aperture (7 mm for visible and near-infrared lasers).

**Aperture** - An opening through which radiation can pass.

**Argon** - A gas used as a laser medium. It emits blue-green light primarily at 448 and 515 nm.

**Attenuation** - The decrease in energy (or power) as a beam passes through an absorbing or scattering medium.

**Aversion Response** - Movement of the eyelid or the head to avoid an exposure to a noxious stimulant, bright light. It can occur within 0.25 seconds, and it includes the blink reflex time.

**Beam** - A collection of rays that may be parallel, convergent, or divergent.

**Beam Diameter** - The distance between diametrically opposed points in the cross section of a circular beam where the intensity is reduced by a factor of  $e^{-1}$  (0.368) of the peak level (for safety standards). The value is normally chosen at  $e^{-2}$  (0.135) of the peak level for manufacturing specifications.

**Beam Divergence** - Angle of beam spread measured in radians or milliradians (1 milliradian = 3.4 minutes of arc or approximately 1 mil). For small angles where the cord is approximately equal to the arc, the beam divergence can be closely approximated by the ratio of the cord length (beam diameter) divided by the distance (range) from the laser aperture.

**Blink Reflex** - See [aversion response](#).

**Brightness** - The visual sensation of the luminous intensity of a light source. The brightness of a laser beam is most closely associated with the radio-metric concept of radiance.

**Carbon Dioxide** - Molecule used as a laser medium. Emits far energy at 10,600 nm (10.6  $\mu\text{m}$ ).

**Closed Installation** - Any location where lasers are used which will be closed to unprotected personnel during laser operation.

**CO<sub>2</sub> Laser** - A widely used laser in which the primary lasing medium is carbon dioxide gas. The output wavelength is 10.6 μm (10600 nm) in the far infrared spectrum. It can be operated in either CW or pulsed.

**Coherence** - A term describing light as waves which are in phase in both time and space. Monochromaticity and low divergence are two properties of coherent light.

**Collimated Light** - Light rays that are parallel. Collimated light is emitted by many lasers. Diverging light may be collimated by a lens or other device.

**Collimation** - Ability of the laser beam to not spread significantly (low divergence) with distance.

**Continuous Mode** - The duration of laser exposure is controlled by the user (by foot or hand switch).

**Continuous Wave (CW)** - Constant, steady-state delivery of laser power.

**Controlled Area** - Any locale where the activity of those within are subject to control and supervision for the purpose of laser radiation hazard protection.

**Diffuse Reflection** - Takes place when different parts of a beam incident on a surface are reflected over a wide range of angles in accordance with Lambert's Law. The intensity will fall off as the inverse of the square of the distance away from the surface and also obey a Cosine Law of reflection.

**Divergence** - The increase in the diameter of the laser beam with distance from the exit aperture. The value gives the full angle at the point where the laser radiant exposure or irradiance is  $e^{-1}$  or  $e^{-2}$  of the maximum value, depending upon which criteria is used.

**Embedded Laser** - A laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the system's lower classification is appropriate to the engineering features limiting accessible emission.

**Emission** - Act of giving off radiant energy by an atom or molecule.

**Enclosed Laser Device** - Any laser or laser system located within an enclosure which does not permit hazardous optical radiation emission from the enclosure. The laser inside is termed an "embedded laser."

**Energy (Q)** - The capacity for doing work. Energy is commonly used to express the output from pulsed lasers and it is generally measured in Joules (J). The product of power (watts) and duration (seconds). One watt second = one Joule.

**Excimer "Excited Dimer"** - A gas mixture used as the active medium in a family of lasers emitting ultraviolet light.

**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.

**Gas Discharge Laser** - A laser containing a gaseous lasing medium in a glass tube in which a constant flow of gas replenishes the molecules depleted by the electricity or chemicals used for excitation.

**Gas Laser** - A type of laser in which the laser action takes place in a gas medium.

**Helium-Neon (HeNe) Laser** - A laser in which the active medium is a mixture of helium and neon. Its wavelength is usually in the visible range. Used widely for alignment, recording, printing, and measuring.

**Infrared Radiation (IR)** - Invisible electromagnetic radiation with wavelengths which lie within the range of 0.70 to 1000  $\mu\text{m}$ . These wavelengths are often broken up into regions: IR-A (0.7-1.4  $\mu\text{m}$ ), IR-B (1.4-3.0  $\mu\text{m}$ ) and IR-C (3.0-1000  $\mu\text{m}$ ).

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

**Irradiance (E)** - Radiant flux (radiant power) per unit area incident upon a given surface. Units: Watts per square centimeter. (Sometimes referred to as power density, although not exactly correct).

**Laser** - An acronym for light amplification by stimulated emission of radiation. A laser is a cavity with mirrors at the ends, filled with material such as crystal, glass, liquid, gas or dye. It produces an intense beam of light with the unique properties of coherency, collimation, and monochromaticity.

**Laser Accessories** - The hardware and options available for lasers, such as secondary gases, Brewster windows, Q-switches and electronic shutters.

**Laser Controlled Area** - See [Controlled Area](#).

**Laser Device** - Either a laser or a laser system.

**Laser Medium (Active Medium)** - Material used to emit the laser light and for which the laser is named.

**Laser Rod** - A solid-state, rod-shaped lasing medium in which ion excitation is caused by a source of intense light, such as a flash lamp. Various materials are used for the rod, the earliest of which was synthetic ruby crystal.

**Laser Safety Officer (LSO)** - One who has authority to monitor and enforce measures to control 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. Under the Federal Standard, a laser in combination with its power supply (energy source).

**Lens** - A curved piece of optically transparent material which, depending on its shape, is used to either converge or diverge light.

**Light** - The range of electromagnetic radiation frequencies detected by the eye, or the wavelength range from about 400 to 760 nm. The term is sometimes used loosely to include radiation beyond visible limits.

**Limiting Aperture** - The maximum circular area over which radiance and radiant exposure can be averaged when determining safety hazards.

**Maintenance** - Performance of those adjustments or procedures specified in user information provided by the manufacturer with the laser or laser system, which are to be performed by the user to ensure the intended performance of the product. It does not include operation or service as defined in this glossary.

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

**Nd:Glass Laser** - A solid-state laser of neodymium:glass offering high power in short pulses. A Nd-doped glass rod used as a laser medium to produce 1064 nm light.

**Nd:YAG Laser** - Neodymium:Yttrium Aluminum Garnet. A synthetic crystal used as a laser medium to produce 1064 nm light.

**Neodymium (Nd)** - The rare earth element that is the active element in Nd:YAG laser and Nd:Glass lasers.

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

**Optical Cavity (Resonator)** - Space between the laser mirrors where lasing action occurs.

**Optical Density** - A logarithmic expression for the attenuation produced by an attenuating medium, such as an eye protection filter.

**Optical Fiber** - A filament of quartz or other optical material capable of transmitting light along its length by multiple internal reflection and emitting it at the end.

**Optical Pumping** - The excitation of the lasing medium by the application of light rather than electrical discharge.

**Optical Radiation** - Ultraviolet, visible, and infrared radiation (0.35-1.4  $\mu\text{m}$ ) that falls in the region of transmittance of the human eye.

**Output Power** - The energy per second measured in watts emitted from the laser in the form of coherent light.

**Power** - The rate of energy delivery expressed in watts (Joules per second). Thus: 1 Watt = 1 Joule x 1  $\text{s}^{-1}$

**Protective Housing** - A protective housing is a device designed to prevent access to radiant power or energy.

**Pulse** - A discontinuous burst of laser, light or energy, as opposed to a continuous beam. A true pulse achieves higher peak powers than that attainable in a CW output.

**Pulse Duration** - The "on" time of a pulsed laser, it may be measured in terms of milliseconds, microseconds, or nanoseconds as defined by half-peak-power points on the leading and trailing edges of the pulse.

**Pulsed Laser** - Laser which delivers energy in the form of a single or train of pulses.

**Pump** - To excite the lasing medium. See [Optical Pumping](#) or [Pumping](#).

**Pumped Medium** - Energized laser medium.

**Pumping** - Addition of energy (thermal, electrical, or optical) into the atomic population of the laser medium, necessary to produce a state of population inversion.

**Radiant Energy (Q)** - Energy in the form of electromagnetic waves usually expressed in units of Joules (watt-seconds).

**Radiant Exposure (H)** - The total energy per unit area incident upon a given surface. It is used to express exposure to pulsed laser radiation in units of  $\text{J}/\text{cm}^2$ .

**Reflection** - The return of radiant energy (incident light) by a surface, with no change in wavelength.

**Refraction** - The change of direction of propagation of any wave, such as an electromagnetic wave, when it passes from one medium to another in which the wave velocity is different. The bending of incident rays as they pass from one medium to another (e.g., air to glass).

**Resonator** - The mirrors (or reflectors) making up the laser cavity including the laser rod or tube. The mirrors reflect light back and forth to build up amplification.

**Ruby** - The first laser type; a crystal of sapphire (aluminum oxide) containing trace amounts of chromium oxide.

**Scanning Laser** - A laser having a time-varying direction, origin or pattern of propagation with respect to a stationary frame of reference.

**Secured Enclosure** - An enclosure to which casual access is impeded by an appropriate means (e.g., door secured by lock, magnetically or electrically operated latch, or by screws).

**Semiconductor Laser** - A type of laser which produces its output from semiconductor materials such as GaAs.

**Service** - Performance of adjustments, repair or procedures on a non-routine basis, required to return the equipment to its intended state.

**Solid Angle** - The ratio of the area on the surface of a sphere to the square of the radius of that sphere. It is expressed in steradians (sr).

**Source** - The term source means either laser or laser-illuminated reflecting surface, i.e., source of light.

**Tunable Laser** - A laser system that can be "tuned" to emit laser light over a continuous range of wavelengths or frequencies.

**Tunable Dye Laser** - A laser whose active medium is a liquid dye, pumped by another laser or flash lamps, to produce various colors of light. The color of light may be tuned by adjusting optical tuning elements and/or changing the dye used.

**Ultraviolet (UV) Radiation** - Electromagnetic radiation with wavelengths between soft X-rays and visible violet light, often broken down into UV-A (315-400 nm), UV-B (280-315 nm), and UV-C (100-280 nm).

**Visible Radiation (light)** - Electromagnetic radiation which can be detected by the human eye. It is commonly used to describe wavelengths in the range between 400 nm and 700-780 nm.

**Wavelength** - The length of the light wave, usually measured from crest to crest, which determines its color. Common units of measurement are the micrometer (micron), the nanometer, and (earlier) the Angstrom unit.

**YAG** - Yttrium Aluminum Garnet, a widely used solid-state crystal composed of yttrium and aluminum oxides and a small amount of the rare earth neodymium.

## APPENDIX B – LASER CLASSIFICATION

Class	Power Output	Description
1	<0.4 $\mu$ W	Considered safe for continuously viewing or are designed in such a way that prevents human access to laser.
2	0.4 $\mu$ W-1 mW	Visible light lasers will not cause eye injury if viewed momentarily. They can possibly present an eye hazard if viewed directly for a long period of time.
3a/R	1 mW-5 mW	Can not damage the eye within 0.25 second of the aversion response or blink reflex. Injury is possible if the beam is viewed with collecting optics or by staring at the direct beam.
3b	5 mW-500 mW	Present an eye and skin hazard from viewing the direct beam or a specular reflected beam. No production of a hazardous diffuse reflection except when viewed with collecting optics. No fire hazard is presented.
4	>500 mW	These are the most hazardous lasers and may cause an eye and skin injury from the direct viewing, specular reflection, and diffuse reflection. These lasers can produce fire and generate hazardous airborne contaminants.

## APPENDIX C – COMMON LASER TYPES AND WAVELENGTHS

**Table B1 – Ultraviolet (0.180  $\mu\text{m}$  – 0.400  $\mu\text{m}$ )**

Laser Type	Wavelength ( $\mu\text{m}$ )
Argon Fluoride	0.193
Krypton Fluoride	0.248
Neodymium:YAG (4 <sup>th</sup> harmonic)	0.266
Argon	0.275, 0.351, 0.363
Xenon Chloride	0.308
Helium Cadmium	0.325
Nitrogen	0.337
Xenon Fluoride	0.351
Neodymium:YAG (3rd harmonic)	0.355

**Table B2 – Visible (0.400  $\mu\text{m}$  – 0.700  $\mu\text{m}$ )**

Laser Type	Wavelength ( $\mu\text{m}$ )
Helium Cadmium	0.442
Rhodamine 6G	0.450, 0.650
Argon	0.457, 0.476, 0.488, 0.514
Copper vapor	0.510, 0.578
Krypton	0.530
Neodymium:YAG (2nd harmonic)	0.532
Helium Neon	0.543, 0.632
Indium Gallium Aluminum Phosphide	0.670
Ruby	0.694

**Table B3 - Near-infrared (0.700  $\mu\text{m}$  – 1.400  $\mu\text{m}$ )**

Laser Type	Wavelength ( $\mu\text{m}$ )
Ti-Sapphire	0.700 – 1.000
Alexandrite	0.720 – 0.800
Gallium Aluminum Arsenide	0.780, 0.850
Gallium Arsenide	0.905
Neodymium:YAG	1.064
Helium Neon	1.180, 1.152
Indium Gallium Aluminum Phosphide	1.310

**Type B4 – Mid-infrared (1.400  $\mu\text{m}$  – 3.000  $\mu\text{m}$ )**

Laser Type	Wavelength ( $\mu\text{m}$ )
Erbium Glass	1.540
Holmium	2.100
Hydrogen Fluoride	2.600 – 3.000



Erbium	2.940
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**Table B5 - Far-infrared (3.000  $\mu\text{m}$  – 1 mm)**

<b>Laser Type</b>	<b>Wavelength (<math>\mu\text{m}</math>)</b>
Helium Neon	3.390
Carbon Monoxide	5.000 – 5.500
Carbon Dioxide	10.6

# **APPENDIX D – UTSA LASER SETUP GUIDELINES**

The following guidelines are provided to assist a PI in planning setup of a laser laboratory involving class 3b and class 4 lasers. No laser setup should be devised without consulting the LSO. No guidelines can universally apply for every laser because of differences in output wavelengths, output powers and output modes. The R&LSC reserves the right to amend safety requirements and recommendations as needed for any single laser or combinations of lasers.

An Application must be submitted and approved by the R&LSC for each laser. Each class 3b and 4 laser must be on UTSA's registration through TXDSHS. The LSO must be notified when lasers are ordered to ensure they are promptly added to the registration.

The Office of Facilities will only perform construction and maintenance work on laser setups. Different lasers will have different requirements for use, and may require different infrastructure and utility support. Specifications for each unique laser being installed, must be provided for review by the Office of Facilities to assure appropriate design features are included in room infrastructure.

## **I. SETUP COSTS**

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New faculty should be made aware of the responsibilities and costs of implementing the UTSA Laser Safety policy and the requirement that adequate safety measures be in place and R&LSC approval granted before commencing laser operations. Existing faculty acquiring class 3b or class 4 lasers must also meet setup requirements and are responsible for securing adequate setup funds with the acquisition of any high-powered laser.

## **II. LASER LOCALITY**

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Laser laboratories that require large amounts of cooling water or power should be placed at ground level when possible to facilitate provision of these utilities and minimize the potential for damaging floods. Designs that require personnel in other laboratories to have emergency egress through laser laboratories should be avoided and no windows should be placed on doors leading to rooms housing lasers. High-powered lasers should be ideally housed in interior rooms that do not have windows or open directly into building corridors. Otherwise, adequate controls must be used to prevent laser beams exiting through windows or into building corridors.

## **III. INTERLOCKS**

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Provision must be made for controlling access to a high-power laser lab. Wiring must be in place between door and light table locations to permit the decision on an individual basis of whether a particular laboratory actually uses a card reader (with individual PIN codes) versus a real interlock, a laser light trap or not, etc. Sufficient wiring should be provided between an entrance control point and laser light tables to allow for the installation of an emergency cutoff (PANIC button) if, for example, a PI wanted to use an interlock-like device purely to provide emergency laser/power shutdown in the event of a burst cooling pipe or other catastrophic accident.