UNIVERSITY of HOUSTON

Environmental Health and Safety

Laser Safety Manual

2020

Preface

LASER SAFETY is the responsibility of all persons at the University of Houston - faculty, staff, students, researchers, etc. The use of lasers at the University of Houston (UH), where a large number of people may be unaware of their exposure to laser radiation hazards, makes strict adherence to federal, state regulations, and university policies important for the safety and protection of members of the university community.

The Radiation Safety Committee, under the functional authority of the Vice President of Research & Technology Transfer is responsible for the Laser Safety Program outlined in this manual. The objective of the Laser Safety Program is to assist all levels of management in fulfilling the University of Houston's commitment to provide a place of employment and learning which is as free as possible from recognized hazards, including laser radiation hazards.

The purpose of the Laser Safety Manual is to assist personnel, students, and management in complying with the state and federal laser radiation regulations and the UH Laser Safety Program.

The Laser Safety Manual is an enforceable component of the Radiation Producing Devices Registration under which the University of Houston is authorized. However, the manual is not intended to be an exhaustive or fully comprehensive reference. Further advice concerning hazards associated with lasers and/or the development of new and unfamiliar procedures should be obtained by consulting the Laser Safety Officer at 713-743-5858 or via email to ehs@uh.edu.

I. Introduction

A. Purpose

Lasers are capable of causing eye injury from the direct beam and specular reflections especially Class 3b and 4. Class 4 lasers are also capable of burning exposed skin, igniting flammable materials and generating hazardous air contaminants; diffuse reflection from Class 4 lasers can also cause eye injury. Additional hazards associated with lasers such as high voltage, high pressure, cryogenics, noise, radiation and toxic gases due to laser operations are also covered in this manual.

The purpose of this manual is to ensure the safe use of lasers at the University of Houston (the University). To achieve this goal, the University is regulated through a Laser Certificate of Registration from the Texas Department of State Health Services Radiation Control Program, under the Texas Administrative Code Chapter 25 §289.301- Registration and Radiation Safety of Requirements for Lasers and Intense-Pulsed Light Devices. The University has also adopted, through the previously cited regulation, the American National Standard for Safe Use of Lasers, ANSI Z136.1 - 2014 which is recognized as a standard for laser safety.

Although lower classification of lasers (Class 1, Class 2, 2a, 3a or 3R) are exempt from registration per 25 TAC 289.301, their use is subject to other applicable requirements of the regulations and the ANSI standard. Users of the above laser class must ensure safe use. Consult with the Laser Safety Officer (LSO) if additional information or guidance is needed.

B. Scope

The UH Laser Safety Program applies to all Class 3b and 4 lasers and to all persons (faculty, staff, and students, etc.) either working directly with or in the vicinity of those lasers at the University of Houston Main Campus, UH Technology Bridge or University of Houston at Sugarland.

C. Responsibilities

1. Principal Investigators (PIs) are responsible for:

a. Complying with university approved procurement guidelines regarding purchase of Class 3b and 4 lasers.
b. Obtaining required approvals from the Laser Safety Officer before engaging a laser vendor for alignment, calibration and/or repair of Class 3b or 4 laser
c. Supervising laser(s) use in the laboratory.
d. Implementing and enforcing the safety recommendations and requirements outlined in this manual.
e. Developing standard operating procedures (SOPs) for the laboratory and obtaining approval of the SOP from the LSO.

f. Providing laser operators with training in operating, administrative and alignment procedures.
g. Ensuring that all lasers in the laboratory are properly classified and labeled.
h. Registering all Class 3b and 4 lasers with the Environmental Health and Safety Department.
i. Completing and ensuring all Authorized Users complete laser safety training prior to laser use and annual refresher trainings.
j. Notifying the LSO in EHS immediately in the event of an injury caused by exposure to a laser beam as described in Section X of this manual.
k. Placing copies of operator and safety manuals and approved SOPs in areas near laser(s) accessible to users.
l. Notify the LSO at (713)743-5858 of stolen, lost, or missing Class 3b or 4 lasers immediately when the event is discovered.

2. Laser Operators (Authorized Users) are responsible for:

a. Following laboratory SOPs.
b. Informing the PI of any deviation from the SOPs.
c. Notifying the PI in the event of an exposure incident (actual or suspected) as well as injuries.
d. Completing the laser safety training and the annual laser safety refresher training.

3. The Environmental Health and Safety Department (EHS) is responsible for:

a. Developing a laser safety manual and revising it when necessary.
b. Conducting safety inspection of Class 3b or 4 laser laboratories and inventories.
c. Providing assistance in evaluating and controlling hazards.
d. Updating the laser safety manual consistent with regulatory changes.
e. Maintaining records of all Class 3b and 4 laser inventory and standard operating procedures.
f. Conducting laser safety training for all personnel working with Class 3b or 4 lasers.
g. Participating in accident/incident investigations involving lasers.

4. Laser Safety Officer (LSO) duties:

The University LSO is a designated staff member who has the knowledge and responsibility to apply appropriate laser radiation protection rules, standards, and practices. The LSO is named and specifically authorized to perform duties specified on the Certificate of Laser Registration issued by the Texas Department of State Health

Services, Radiation Control Program. In addition to the items listed above, the duties of the LSO also include:

a. Assumes control and has the authority to institute corrective actions including shutdown of operations when necessary in emergency situations or unsafe conditions.
b. Specify whether any changes in control measures are required following any service and maintenance of lasers that may affect the output power or operating characteristics or whenever deliberate modifications are made that could change the laser class and affect the output power or operating characteristics.
c. Provide guidance on the proper selection and use of protective eyewear and other safety measures.
d. Ensure compliance with the laser requirements and with any engineering or operational controls specified by the University.
e. In situations where engineering controls may be inappropriate, such as medical procedures, the LSO shall specify alternate controls to obtain equivalent laser safety protection.
f. Within 24 hours of discovery of an injury, report to the Texas Department of State Health Services (DSHS) Radiation Control Program (the agency) each injury involving any Class 3b or 4 laser registered by the University, other than intentional exposure of patients for medical purposes, that may have caused, or threatens to cause, an exposure to an individual with second or third-degree burns to the skin or potential injury and partial loss of sight.
g. Within 24 hours of discovery of a medical event or of any injury to or death of a patient, report to the agency each injury involving any Class 3b or 4 laser registered by the University.
h. Within 24 hours of discovery of a stolen, lost, or missing laser, report to the agency incident involving any Class 3b or 4 laser registered by the University.
i. A report in writing to the regulatory agency within 30 days from notification of the events described above in subsections f, g, and h.

II. Personnel Training and Qualifications

Only qualified personnel are permitted to operate laser(s). The PI will identify qualified personnel based on departmental training, technical training and other appropriate learning experience.

All operators operating Class 3b and Class 4 lasers are required to complete the laser safety training conducted by EHS **prior** to working with lasers. Before operating a Class 3b or 4 laser, users shall:

1. Review the Laser Safety Manual

2. Review the SOP for the specific laser to be used. Most lasers are provided with instructions for safe operations by the manufacturer; however, sometimes these are not well suited to specific applications due to special use conditions. For this reason, an SOP

is required for all Class 3b and 4 lasers at the University. Please contact the LSO for assistance in developing an SOP.

a. Approved SOP's for all active Class 3b and 4 lasers shall be available for review during laboratory and laser equipment inspections. These SOPs shall be maintained with the laser equipment for reference by the operator and maintenance or service personnel. Contact the LSO for a standardized SOP Laser Template.

3. Receive training from the PI or laboratory supervisor covering safe operation of the specific laser(s) to be used, administrative procedures, alignment procedures and other applicable SOPs.

III. Laser Procurement Procedures

Notify the Laser Safety Officer (LSO) at 713-743-5858 prior to purchasing, fabricating, or acquiring Class 3b and/or 4 lasers including modification to existing lasers. This is necessary to ensure that the system or unit can be safely installed and operated at designated locations. To ensure personnel safety and compliance with applicable regulations, laser use areas may require special design considerations depending on the laser hazard classification. Consult with the LSO for further guidance.

Class 3b and 4 lasers, regardless of dollar amount, must only be ordered via Purchase Requisition through the Purchasing Department per the University Manual of Policies and Procedures (MAPP) 04.01.01.

All Purchase Requisitions for Class 3b and 4 lasers must be approved in advance by the LSO. Transferred equipment and donations must also receive pre-approval. The LSO will verify that the receiving PIs are authorized to use the lasers.
Note: The Pre-Approval Form for Requisitions-Addendum B for Hazardous Items & Vehicles (available at https://uh.edu/office-of-finance/purchasing/Forms/) must be used to obtain pre-approval for the above purchases. For more information, visit https://uh.edu/policies/mapps/

Laser safety devices should be purchased along with the laser, and installed with the laser when received. Failure to plan and install safety devices as required will delay the final authorization for use of the laser.

Purchase Order information must include:

1. Laser, type, model, maximum operating power and wavelength(s)
2. Brief Description or Copy of Brochure/Manual (electronic preferred)
3. Name of the PI
4. Proposed use location (must be a UH Building and laboratory location)
5. Directions to deliver shipment (must be a UH Building and laboratory location).

IV. Laser Subregistration, Amendments, and Recording Keeping

A. Laser Subregistration Application

All Class 3b and 4 lasers are required to be registered with the Texas Department of State Health Services under the University of Houston's Laser Registration. Classes 1, 2 and 3a (3R) lasers are not required to be registered.

In addition to registration, possession and use of all Class 3b and 4 lasers at the University of Houston must be approved by the LSO and receive authorization from the Radiation Safety Committee.

Principal Investigators wishing to possess lasers for the first time at the University must complete an Application for Laser Subregistration and submit to Environmental Health and Safety (EHS) via email to ehs@uh.edu for review by the LSO. Application forms and instructions can be found at https://uh.edu/ehls/about/forms/. The application must include all lasers, laser users, equipment locations, and procedures. Anyone not listed on the subregistration permit must not be allowed to work with lasers for any reason. The lasers must not be used until final approval is given by the Radiation Safety Committee or interim approval from the LSO.

The use of lasers often requires specialized safeguards. Investigative procedures vary widely as do applicable safety techniques. The information provided on the application will enable the LSO to recommend necessary safety measures and assist the PI in implementing these measures. It is important that all requested information be included and the application fully completed. Radiation Safety shall perform compliance inspections prior to laser use (pre and post-laser system setup).

The LSO will present all applications to the Radiation Safety Committee for approval. The LSO may grant interim approval to PIs until the next Radiation Safety Committee meeting. When the LSO finds reason to grant an interim approval to a new PI prior to Radiation Safety Committee's approval, it will be limited to 90 days to allow sufficient time for a committee meeting (with quorum) to discuss and then approve, deny, or conditionally issue a new subregistration permit to the PI. A temporary subregistration permit with a 90 day expiration date will be issued until the Radiation Safety Committee approval is obtained at which time a final permit will then be issued.

Approved PIs will receive an Authorization to Use Lasers, which is proof of authorization at the University and may be submitted with Research Grant Proposals. Once approved, the PI will remain authorized until either voluntary subregistration termination by the PI or the sublicense is revoked by the Radiation Safety Committee for noncompliance.

B. Laser Subregistration Amendment Guidelines

Authorized PIs planning to make a change to their subregistration must complete a Laser Subregistration Amendment Form and submit to the LSO for review. These changes may include the following:

1. Addition or removal of a Class 3b or Class 4 laser
2. Addition or removal of an Authorized User
3. Addition or removal of an authorized use location
4. Addition or removal of an authorized laser use procedure
5. Any additional change from the original Laser Subregistration Application that was not previously approved.

The Laser Subregistration Amendment form and instructions may be obtained electronically at https://uh.edu/ehls/about/forms/ .

C. Inventory and Record Keeping Requirements

The University is required by the Laser Certificate of Registration to inventory all Class 3b and Class 4 lasers in their possession at an interval **not to exceed one year**. The laser inventory will typically be completed during the annual laser safety inspections conducted by EHS.

Class 3b and 4 laser inventory is required to be maintained for regulatory agency inspection and include:

1. Manufacturer's Name
2. Model and Serial Number of the laser
3. Description of the laser
4. Location of the laser

The University is also required to maintain records of receipt, transfer, and disposal of all Class 3b and Class 4 lasers to include:

1. Manufacturer's Name
2. Model and Serial Number of the laser
3. Date of receipt, transfer, and disposal
4. Name and address of person laser(s) received from, transferred to, or disposed by
5. Name of individual recording the information

Based on the above information, it is important that all PIs notify the LSO immediately of any changes to their laser inventory (including procuring, making, selling, leasing, transferring, or lending lasers) or laboratory personnel.

D. Transfer of lasers from University's main campus to the UH Technology Bridge and or UH Sugar Land

Changes in inventory of lasers at the University's Main campus, Sugarland campus and Technology Bridge locations must be reported to the state agency via the Radiation Safety office. Consequently, PIs intending to transfer their lasers between the listed locations must notify the LSO before doing so.

V. Laser Services at the University of Houston

The university is required by the Texas Department of State Health Services in 25 TAC §289.301(j)(5) to ensure that vendors are duly registered with the state agency prior to engaging them for laser services. Laser services include alignment, calibration, and/or repair of Class 3b or 4 lasers.

PIs are responsible for notifying the Laser Safety Officer prior to engaging a vendor for these services. Submit the vendor's laser certificate of registration or reciprocity of licensing and registration to the Radiation Safety Officer along with the notification.

VI. Laser Light Shows

Persons or entities intending to conduct a laser light show are required per 25 TAC §289.301(g)(7) to apply for and obtain a certificate of laser registration for the light show before beginning any laser light show.

The following documents must be submitted to the University of Houston's Laser Safety Officer at least 7 days in advance regarding any planned light shows:

- The vendor's certificate of laser registration from DSHS
- A valid variance issued from the Food Drugs Administration (FDA) for the laser intended to be used with all applicable documents required by the variance,
- The copy of the written notice of the show (NRC Form 301-3) submitted to the Texas DSHS.

VII. Laser Use on Humans

The following applies to all PIs and authorized laser users intending to use lasers on humans:

1. Individuals shall not use lasers on humans except as:
    a. authorized by the Texas Department of State Health Services
    b. under the supervision of a licensed practitioner of the healing arts and
    c. the use of lasers on humans are within the scope of practice of their professional license.

2. Individuals shall not be intentionally exposed to radiation above the maximum permissible exposure levels (MPE) unless such exposure has been authorized by a licensed practitioner of the healing arts.
3. Exposure of an individual for training, demonstration or other non-healing arts purposes is prohibited unless authorized by a licensed practitioner of the healing arts.
4. Exposure of an individual for the purpose of research is prohibited, except as authorized in research studies. Any research using radiation producing devices on humans must be approved by an institutional review board (IRB) as required by the Code of Federal Regulations. The IRB protocol must include at least one practitioner of the healing arts to direct use of the laser.
5. Documentation of laser equipment calibration and maintenance must be maintained for inspection by radiation safety and/or any external agents.
6. PIs overseeing laser use on humans must develop procedures to verify that such activities are conducted by board licensed practitioners with valid credentials.
7. Procedures for required reporting of a medical event or injury/death of patient as listed in Section X of this manual, consistent with notification requirements in 25 TAC 289. 301 (z), (aa), (bb) and (cc) must be followed.
8. PIs intending to use lasers on humans must coordinate with LSO.

VIII. Lasers Receipt, Setup, Documents, Use, and Laboratory Design Guidelines

A. Receipt, Setup, Documentation, and Usage

The LSO must be notified when a laser arrives and when it is set up. The LSO must document installation and register the laser with DSHS Radiation Control Program within 30 days of laser installation to maintain current registration information for the University Laser Certificate of Registration. Radiation Safety personnel will provide assistance to any PI as needed. Laser operations post installation is not permitted until the LSO has inspected and approved the laboratory set-up and safety provisions prior to laser operations.

The LSO will require copies of specific documentation for review. Copies of these documents are required to be sent to the LSO at EHS via e-mail to ehs@uh.edu. All records should be clearly identified, neatly organized, and maintained in one location in the lab. This will assist the PI and the University to maintain compliance with applicable regulatory requirements.

Documentation includes:

1. Equipment Manuals
2. Purchase records
3. Receipt/Installation records (Includes transfers or donations, both internal and external)
4. Standard operating procedures* for each Class 3b and 4 laser including:
    a. Start-up, shut-down

b. Safety device by-pass, alignment, and emergency
c. Safety glasses
d. Engineering Controls/Safety devices (interlocks, warning lights, curtains, etc.)

Note: Standard Operating Procedures must be reviewed annually, signed by the PI and acknowledged by Authorized Users

5. Calibration, maintenance, and modification records
6. Other information may be requested as necessary.

Standard Operating Procedures template provided by the LSO.

Radiation Safety personnel will inspect the laser setup before operation begins. The PI may only turn on the laser for test procedures in the initial setup. All safety devices must be installed and operational. The laser must not be used without the final approval of the LSO. The LSO will grant final approval for use upon full compliance.

Lasers must also be inspected by Radiation Safety personnel at initial installation, after a move, and whenever maintenance or modifications affect the beam output or laser hazard classification. It is the responsibility of the PI to notify the LSO immediately in the event of the above. Door signage will always be supplied and posted by Radiation Safety personnel. Please call EHS at 713-743-5858, if laser signage is missing, defaced or needs an update.

B. Design Guidelines for Class 4 Laser Laboratories

This section will assist PI and Project Managers in the design, construction and renovation of Class 3b & 4 laser laboratories at the University.

The guidelines comply with requirements specified in the most current edition of ANSI Z136.1, American National Standard for Safe Use of Lasers. In some cases, the design will be modified based on the PIs research proposal. If the laser classification intended for use is not specified by the researcher, Class 4 standard design guidelines should be followed. If the PI intends to use a Class 4 laser in the future, this design guideline will save costs of future remodeling. Design considerations include hazard warning signage on entryway, Controlled Entry (Access Control), Laser Beam Containment Curtain, Control Circuit, Laboratory Layout. Additional design considerations covered in the guidelines include, protection from Toxic Plumes and Laser Generated Effluents, Liquids in the Laboratory, Cable Runs, Optical Bench. Contact the Laser Safety Officer at 713-743-5858 for clarification.

C. Guidelines for Radiation Laboratories Changes and Services

Changes and services in a laser laboratory should be done properly and in a safe manner in coordination with laboratory personnel. These include laboratory moves, modifications, maintenance, and housekeeping. Special considerations must be given for equipment moves, transfers, or disposal.

All obsolete lasers and/or radiation labeled equipment should also be disposed in coordination with the LSO using an amendment (see section IV). The PI must also submit an amendment application to delete a closed lab from their sublicense or subregistration.

UH Facilities Services will not move and Property Management will not accept or dispose of any laser equipment without prior authorization and documentation from the LSO and EHS Department.

The LSO will verify that the laboratories are completely cleared of laser equipment prior to close out. Radiation Safety personnel will also remove all laser signage.

PIs authorized to use laser devices leaving the University must complete the PI Checkout Procedure; contact EHS at 713-743-5858 or via email to ehs@uh.edu to obtain the form. In addition, the PI must notify the LSO with the final departure date from the University via email at least 30 days prior to departing. Radiation Safety Personnel will inspect the location on the final date of occupancy or within two (2) business days to clear and release the room for unrestricted use by applicable college or department.

Maintenance and /or Laboratory Modification: All work with lasers must cease while the modification or maintenance is being carried out. Direct support and supervision by laboratory personnel should be provided as needed for UH Facilities or external contractors. Custodial personnel or routine maintenance workers must also be given specific instructions on how and when such work can be performed.

IX. Radiation Safety Requirements for Class 3b and 4 Lasers

The University's Laser Safety Program sets forth controls and safety guidance for research and educational activities involving lasers. The fundamental objective is to ensure exposures are at or below the laser specific maximum permissible exposure (MPE). The MPE is defined as the level of laser radiation to which an unprotected person may be exposed without adverse biological changes in the eye or skin.

To assist users, the distinction between Operation, Maintenance and Service as it relates to lasers or laser systems are defined below:

1. Operation refers to the performance of the laser or laser system over the full range of its intended functions (normal operation).
2. Maintenance is a task(s) performed to support routine performance of the laser or laser system, e.g. cleaning and replenishing expendables. Maintenance tasks, generally provided in the manuals, are considered preventative maintenance and may or may not involve access to the beam.
3. Service occurs less frequently than maintenance and often requires access to the laser beam. Tasks include replacing laser resonators, replacing and/or repairing laser components and must be performed by a certified technician or manufacturer

representative. Service is generally performed to bring the laser or laser system back to full and normal operational status.

For the purpose of this manual, operations must be performed by PIs and Authorized Users listed on the PI Subregistration (permit). Maintenance activities must be performed by the PI or designated Authorized Users specified on the SOP, according to procedures described on the SOP. Service functions must never be performed by the PI or Authorized User, except that they are qualified and certified to perform such functions and can demonstrate qualifications and certifications through documentation.

Control measures used to prevent exposure to laser radiation above MPE are outlined below.

A. Protective Housing

Each laser shall have a protective housing that prevents human access during the operation of the laser and collateral radiation that exceeds the limits of Class 1 laser.

Protective housings or service panels enclosing embedded Class 3b and 4 lasers shall be interlocked or fastened closed requiring special tools for removal. When it is necessary to remove protective housings or service panels, a temporary laser controlled area shall be established. A temporary laser controlled area will not have the built-in protective features that are part of a laser-controlled area, but shall provide all safety requirements to protect personnel within and outside the area. Requirements for the temporary laser controlled area include, but are not limited to:

1. Restricted access to the area.
2. Control of the beam to prevent the beam and reflections from extending beyond the area.
3. Removal of reflective materials in and near the beam path.
4. Appropriate laser eye protection if there is a possibility of exposure to laser radiation above the MPE.
5. A warning sign posted outside the area. (See Signs & Postings, Labels, for the warning sign and labelling requirements.)
6. Notify Radiation Safety if setting up a temporary controlled area.

B. Safety Interlocks

A safety interlock, to ensure that radiation is not accessible above the MPE limits, shall be provided for any portion of the protective housing that by design can be removed or displaced during normal operation or maintenance, and thereby allows access to radiation above the MPE limits.

Adjustment during operation, service, testing, or maintenance of a laser containing interlocks shall not cause the interlocks to become inoperative or the radiation to exceed MPE limits outside the protective housing except where a laser controlled area is established.

For pulsed lasers, interlocks shall be designed so as to prevent firing of the laser; for example, by dumping the stored energy into a dummy load.

For continuous wave lasers, the interlocks shall turn off the power supply or interrupt the beam; for example, by means of shutters.

An interlock shall not allow automatic accessibility of radiation emission above MPE limits when the interlock is closed. Either multiple safety interlocks or a means to preclude removal or displacement of the interlocked portion of the protective housing upon interlock failure shall be provided, if failure of a single interlock would allow human access to high levels of laser radiation.

C. Beam Control

Ensure the beam height is not at the normal eye position of a person in a standing or seated position. Position the laser so that the beam is not directed toward doorways or aisles. Securely mount the laser system to maintain the beam in a fixed position during operation and limit beam movements during adjustments. Ensure beam path is well defined and controlled. Terminate the beam at the end of its useful path.

Confine beams and reflections to the optical table. The addition of beam-stopping panels to the sides of the optical table is recommended. If the beam path extends beyond the optical table, a physical barrier shall be used to prevent accidental exposure. Have only diffusely reflection materials in or near the beam path, where feasible. Absorb unwanted reflections. Scatter is not permitted.

D. Infrared Lasers

The beam from an infrared laser shall be terminated in a fire-resistant material where necessary. Inspection intervals of absorbent material and actions to be taken in the event or evidence of degradation shall be specified in the laboratory operating and safety procedures.

E. Ultraviolet (UV) Lasers

Exposure to UV radiation shall be minimized by using beam shields and clothing which attenuate the radiation to levels below the MPE for the specific UV wavelengths.

F. Nominal Hazard Zone (NHZ)

Where applicable, in the presence of unenclosed Class 3b and Class 4 laser beam paths, an NHZ shall be established. If the beam of an unenclosed Class 3b and Class 4 laser is contained within a region by adequate control measures to protect personnel from exposure to levels of radiation above the appropriate MPE, that region may be considered to be the NHZ.

G. Viewing Optics and Windows

All viewing ports, viewing optics, or display screens included as an integral part of an enclosed laser or laser product shall incorporate suitable means, such as interlocks, filters, or attenuators, to maintain the laser radiation at the viewing position at or below the applicable MPE under any conditions of operation of the laser.

All collecting optics, such as lenses, telescopes, microscopes, endoscopes, etc., intended for viewing use with a laser shall incorporate suitable means, such as interlocks, filters, or attenuators, to maintain the laser radiation transmitted through the collecting optics to levels at or below the appropriate MPE. Normal or prescription eyewear is not considered collecting optics.

H. Warning Systems

Each Class 3b, or 4 laser or laser product shall provide visual or audible indication during the emission of accessible laser radiation. For Class 3b lasers except for those less than 5 mW peak visible laser radiation (Class 3R), and Class 4 lasers, this indication shall be sufficient prior to emission of such radiation to allow appropriate action to avoid exposure. Any visible indicator shall be clearly visible through protective eyewear designed specifically for the wavelength(s) of the emitted laser radiation. If the laser and laser energy source are housed separately and can be operated at a separation distance of greater than two meters, both laser and laser energy source shall incorporate visual or audible indicators. The visual indicators shall be positioned so that viewing does not require human access to laser radiation in excess of the MPE.

I. Controlled Area

For Class 3b lasers, except those less than 5 mW visible peak power (Class 3R) or Class 4 lasers, a controlled area shall be established when exposure to the laser radiation in excess of the MPE or the collateral limits is possible. Each controlled area shall be posted by proper laser signage and access to the controlled area shall be restricted. All laser system components must be contained within the laser controlled area as no storage is permitted in corridors.

1. Class 3b Laser-Controlled Area

a. Only personnel trained in the operation of the laser and laser safety shall be permitted to operate the laser or laser system.
b. An individual knowledgeable in laser safety shall directly supervise the laser-controlled area.
c. The area shall be posted with the appropriate warning signs.
d. Restrict access to the laser controlled area.
e. Control the beam to prevent any misdirected beams or reflections.
f. Provide eye protection for all personnel working in the laser-controlled area.
g. Cover all windows and other openings to prevent laser radiation from extending beyond the laser-controlled area.

2. Class 4 Laser-Controlled Area

All of the requirements for a Class 3b laser-controlled area must be met. In addition, one of the following entryway controls must be incorporated into a Class 4 laser.

a. Non-Defeatable Entryway Safety Controls (Preferred): Non-defeatable safety latches or interlocks that deactivate the laser or reduce the output to levels below the MPE in the event of unexpected entry are the preferred method of entryway control.
b. Defeatable Entryway Safety Controls: if non-defeatable controls limit the intended use of the laser, defeatable entryways safety controls may be used. Defeatable entryway controls allow authorized personnel to override the controls. Defeatable entryway controls may be used only if there is no laser radiation hazard at the point of entry. Personnel must be properly trained and provided with adequate personal protective equipment.
c. Procedural Entryway Controls: if safety latches or interlocks are not feasible, procedural entryway controls may be used. When procedural entryway controls are used, the following conditions must be met:
    i. All authorized personnel shall be adequately trained by the PI and such training documentation should be maintained.
    ii. Personal protective equipment shall be provided.
    iii. A door, barrier, screen or curtain(s) shall be used to block or attenuate the laser radiation below the MPE at the entryway.
    iv. The entryway shall be equipped with a lighted laser warning sign that indicates the laser is operating.

For Class 4 indoor controlled areas, during tests requiring continuous operation, the individual in charge of the controlled area shall be permitted to momentarily override the safety interlocks to allow access to other authorized personnel if it is clearly evident that there is no optical radiation at the point of entry, and if necessary protective devices are being worn by the entering personnel.

When the removal of panels or protective covers and/or overriding the interlocks becomes necessary, such as for servicing, testing, or maintenance, and accessible laser radiation exceeds the MPE and the collateral limits, a temporary controlled area shall be established.

J. Key Control

Each Class 3b and Class 4 laser shall incorporate a key-actuated or computer-actuated master control. Computer-actuated master controls shall have passwords and users must log-off when system is not in use. The key shall be removable and the Class 3b and Class 4 laser shall not be operable when the key is removed. When not being prepared for operation or is unattended, the key will be removed from the device and stored in a location away from the machine.

K. Eye Protection

When protective eyewear is required, the installation shall provide protective eyewear for all concurrent users plus one spare.

Protective eyewear shall be worn by all individuals with access to Class 3b and/or Class 4 levels of laser radiation. Protective eyewear devices shall provide a comfortable and appropriate fit all around the area of the eye; be in proper condition to ensure the optical filter(s) and holder provide the required optical density or greater at the desired wavelengths and retain all protective properties during its use; be suitable for the specific wavelength of the laser and be of optical density adequate for the energy involved; have the optical density or densities and associated wavelengths(s) permanently labeled on the filters or eyewear; and examined, at intervals not to exceed 12 months, to ensure the reliability of the protective filters and integrity of the protective filter frames.

Unreliable eyewear shall be removed from use and discarded. This includes any eyewear that is damaged (scratched lenses), broken, or do not function as intended.

Contact EHS, Radiation Safety, for assistance in determining appropriate optical density for laser eyewear as well as eyewear inspection. See Appendix B for more information.

L. Skin Protection

When there is a possibility of exposure to laser radiation that exceeds the MPE limits for the skin, appropriate use of protective gloves, clothing, or shields shall be required.

M. 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.

If the exterior of a confocal microscope is labeled as Class 3b or 4, then the applicable requirements for Class 3b and 4 lasers shall be followed. Only manufacturer authorized representatives or approved vendors shall be engaged to perform services on confocal microscopes. A vendor must possess a certificate of laser registration for alignment, calibration, and/or repair from the applicable Texas Agency before providing alignment, calibration, and/or repair of Class 3b or 4 lasers or confocal microscopes. Out of state registered vendors must obtain a reciprocity of licensing and registration https://dshs.texas.gov/radiation/reciprocity.aspx. PIs must notify the Laser Safety Office prior to engaging a vendor for such services.

N. Controls for Non-Beam Hazards

1. Electrical Hazards - The use of lasers or laser systems presents an electric shock hazard. Most lasers contain high-voltage power supplies and capacitors or capacitor banks that store lethal amounts of electrical energy. Exposures may occur from contact with energized components operating at potentials of 50 volts and above. These exposures most often occur during set up or installation, maintenance, modification and service when protective covers are removed.

   To reduce electrical hazards:
   a. When protective housings or covers will be removed, potentially exposing energized components, the following measures must be followed:
      i. Enclose high voltage sources and terminals whenever possible.
      ii. Turn off power and ground all high voltage points before working on power supplies.
      iii. Verify that each capacitor is discharged and grounded prior to working near the capacitor. (Capacitors must be equipped with bleeder resistors, discharge devices or automatic shorting devices.)
      iv. Do not wear rings, watches or other jewelry when working with or near electrical equipment.

2. Laser-Generated Air Contaminants (LGAC) - Air contaminants may be 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.

   Concentrations of LGAC must be maintained below the exposure limits specified by Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH) or American Conference of Governmental Industrial Hygienists (ACGIH). There are three major control measures to reduce the concentration of LGAC to acceptable levels:
      i. Use local exhaust ventilation to remove the LGAC at the point of generation. Local exhaust ventilation should be vented to the outside.
      ii. Isolate the process whenever possible.
      iii. Respiratory protection shall be used only when engineering controls are not feasible. The EHS must be contacted prior to wearing a respirator. Refer to the University's Respiratory Protection Program for more information.

3. Fire Hazards - Class 4 laser beams can ignite flammable solvents, gases and combustible materials. To reduce fire hazards:

i. Terminate laser beams with non-combustible materials
ii. Bring only necessary materials into the laser area.
iii. Store flammable and combustible solvents and materials properly and away from the laser beam.

4. Explosion Hazards - High-pressure arc lamps, filament lamps and capacitor banks may explode if they fail during operation. The laser target and elements of the optical train may shatter during operation. To reduce explosion hazards:
    i. Enclose high-pressure arc lamps and filament lamps in housing that can withstand an explosion if the lamp disintegrates.
    ii. Enclose the laser target and optical train in protective housing during laser operation.
    iii. Ensure that capacitors are equipped with current-limiting devices and are shielded.

5. Compressed Gas - Hazardous gases are used in some laser applications including chlorine, fluorine, hydrogen chloride and hydrogen fluoride. Fill gases used for optical tables are highly pressurized and hazardous when released. Storage of gas cylinders in corridors is not permitted. Refer to the Laboratory Safety Manual at https://uh.edu/ehls/about/manuals/lsm/laboratory-safety-manual.pdf for more information on compressed gas safety.

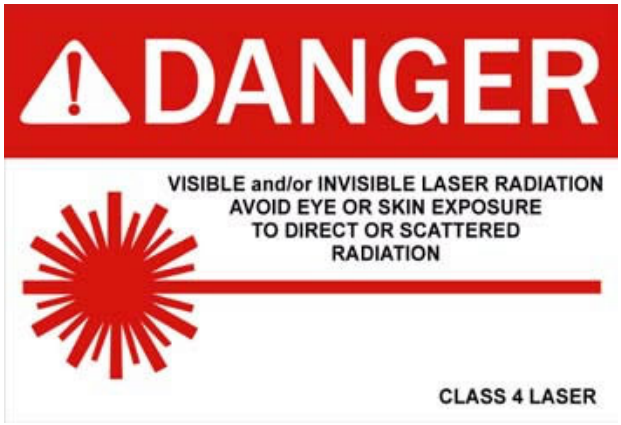
6. Laser Dyes and Solvents - Laser dyes are complex fluorescent organic compounds that are dissolved in a solvent to form a lasing medium. Some dyes are highly toxic or carcinogenic. Most solvents suitable for dye solutions are flammable and toxic by inhalation and/or skin absorption. The following measures shall be followed when working with dyes:
    i. Obtain safety data sheets (SDS) for all dyes and solvents prior to working with them. SDS resources are available at the EHS website https://uh.edu/ehls/general/general-safety/sds/index.php
    ii. Prepare and handle dye solutions in a working fume hood.
    iii. Use disposable bench covers
    iv. Wear a lab coat, safety glasses and appropriate gloves.
    v. Pressure test all dye laser components before using dye solutions. Pay particular attention to tubing connections.
    vi. Install spill pans under pumps and reservoirs.
    vii. For more information regarding safe chemical work practices, refer to the Chemical Hygiene Plan at https://uh.edu/ehls/about/manuals/.

O. Signs and Postings

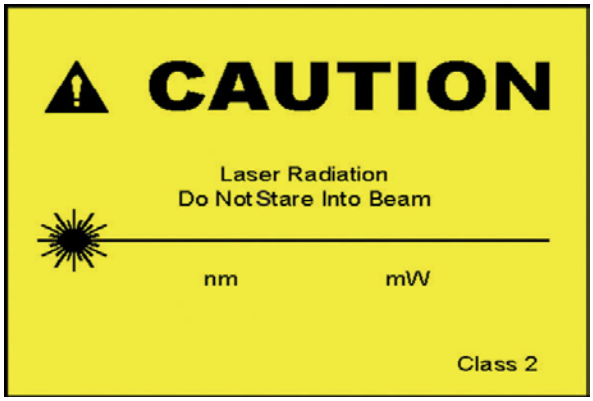
The laser controlled area shall be conspicuously posted with signs to notify individuals of the hazards present. As such, all access points to a laser controlled area with Class 3b or Class 4 lasers must be marked with approved laser warning signs.

Laser hazard signs on laboratory doors are provided and posted by Radiation Safety. Please contact Radiation Safety for additional or replacement signs or postings.

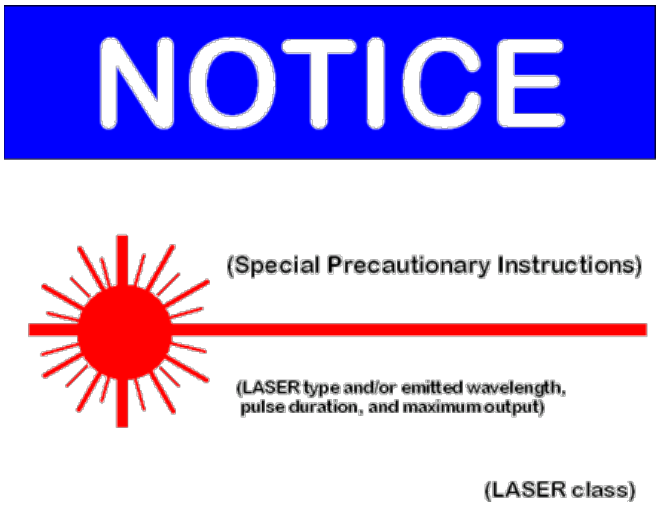
1. Lighted Warning Signs - Entrances to all laboratories where a Class 4 laser is present shall have a lighted warning sign that is activated when the laser is energized. A warning light is also acceptable.
2. Written Warning Signs - The following warning signs are required to be posted at the entrances to laboratories where lasers are present:
    i. All laboratories where a Class 3b or Class 4 laser is present shall have a Danger sign on the door(s) to the laboratory that conforms to ANSI Z136.1-2007.
    ii. Laboratories with a Class 3a or 3R laser that generates a beam with an irradiance or radiant exposure equal to or greater than the MPE shall also have a "Danger" sign affixed to the door(s). The Danger sign shall indicate the precautionary instructions or protective actions required, the type of laser or wavelength, the pulse duration (if applicable), the maximum output and the class of the laser or laser system. The sign shall use the symbols, color and layout shown in the example below.



    iii. All laboratories where a Class 2 or Class 3a or 3R laser is present shall have a Caution sign on the door(s) to the laboratory that conforms to ANSIZ136.1-2007. (Class 3a or 3R lasers that generate a beam with an irradiance or radiant exposure equal to or greater than the MPE shall have a "Danger" sign.) The Caution sign shall indicate the precautionary instructions, the type of laser or wavelength and the class of the laser system.



iv. The outside boundary of a temporary laser controlled area shall be posted with a Notice sign that conforms to ANSI Z136.1-2007. The Notice sign shall indicate the reason for the temporary controls, the precautionary instructions or protective actions required, the type of laser or the wavelength, the pulse duration (if applicable), the maximum output and the class of the laser. The sign shall use the symbols, color and layout shown in the example below.



P. Labels

Lasers shall be properly labeled as follows:

1. All Class 2, Class 3a or 3R, Class 3b and Class 4 lasers and laser systems shall have a label conspicuously affixed to the housing that conforms to ANSI Z136.1-2007. The label shall indicate the precautionary instructions or protective actions required, the type of laser or the wavelength, the pulse duration (if applicable), maximum output and the class of the laser or laser system. The label shall incorporate the sunburst symbol. Manufacturers are required to label lasers in accordance with the Federal Laser Product Performance Standard (21CFR1040.10.) These labels satisfy this

requirement. Contact the EHS for label specifications if the laser was not labeled by the manufacturer, or if it was modified or built in the laboratory.

2. All removable protective housings shall have a label affixed in a conspicuous location that conforms to ANSI Z136.1-2007. The label shall indicate the hazard of the enclosed laser. This label does not need to contain the sunburst symbol. Contact Radiation Safety for label specifications.

X. Injury or Medical Event

Any injured individual must seek immediate medical attention. During emergencies, call UHPD at 713-743-3333. After medical attention has been obtained, the PI shall notify the Laser Safety Officer (LSO) at 713-743-5858 if the injury was due to laser exposure. Notification must be provided within 12 hours of the event.

The LSO shall also be notified within 48 hours of any non-injury incident (near miss) which involves potential exposure to laser radiation exceeding the MPE. A written summary of an injury or non-injury incident shall be forwarded to the LSO no later than five (5) working days following the incident. Records of any incident shall be maintained by the PI and the LSO.

College of Optometry

PIs over registered lasers used for clinical practice under University's Registration must notify the LSO at (713) 743-5858 within 12 hours of discovery of a medical event or injury/death of a patient.

XI. Annual Laboratory Laser Safety Inspections

Lasers safety inspections are conducted periodically by Radiation Safety personnel to ensure regulatory compliance. Notifications will be sent to the PIs in advance to schedule the inspection, however, an inspection may be conducted at ANY TIME without prior notice to ensure radiation hazards from lasers are properly controlled.

The inspections shall include, but are not limited to:

1. A determination that all laser protective devices are labeled correctly and functioning within the design specifications and properly chosen for lasers in use
2. A determination that all warning devices are functioning within their design specifications
3. A determination that the laser-use area is properly controlled and posted with accurate warning signs
4. A re-evaluation of potential hazards from surfaces that may be associated with beam paths; and additional surveys that may be required to evaluate the primary and collateral radiation hazard incident to the use of lasers.

5. An inventory of all Class 3b and 4 lasers.
6. Verification of all Authorized Users for the following:
    a. Current training
    b. Addition of new users
    c. Deletion of inactive or removed users

A copy of the Laser Lab Inspection checklist may be obtained by contacting Radiation Safety at (713)743-5858 or email to ehs@uh.edu.

Appendix A

Laser Classifications (*ANSI Z136.1-2014*)

Class 1 and 1M - Exempt Lasers

- Produce levels of radiation that have not been found to cause biological damage
- This group is normally limited to gallium-arsenide lasers or certain enclosed lasers
- Incorporated into consumer or office machine equipment

Safety Precautions

- No laser specific rules, however general lab safety rules still apply

Class 2 and 2M - Low power and low risk

- Produce radiation that could cause eye damage after direct, long term exposure
- Hazardous only if viewer overcomes natural aversion response to bright light and continuously stares into source (Natural aversion response is the movement of the eyelid or the head to avoid an exposure to a noxious stimulant or bright light and can occur within 0.25 sec). Like blinding oneself by forcing oneself to stare at the sun for more than 10 to 20 seconds.

Safety Precautions

- Never permit a person to stare into the laser source
- Never point the laser at an individual's eye

Class 3R (formerly 3A) – Low Risk or Medium Power

- Higher irradiance than Class 2 lasers with danger safety precautions requiring strict adherence to safety precautions.

Safety Precautions

- Never permit a person to stare into the laser source
- Never point the laser at an individual's eye
- Operate the laser only in a controlled area

Class 3B - Moderate Risk or Medium Power

- Produce radiation powerful enough to injure human eye tissue with 1 short exposure to the direct beam or its direct reflections off a shiny surface.
- Does not produce hazardous diffuse reflections under normal use,
- Not usually capable of causing serious skin injury.

Safety Precautions

- Do not aim the laser at an individual's eye
- Permit only experienced personnel to operate the laser
- Enclose the beam path as much as possible.
- Even a transparent enclosure will prevent individuals from placing their head or reflecting objects within the beam path
- Termination should be used at the end of the useful paths of the direct and any secondary beams
- Operate the laser only in a restricted area
- Place the laser beam path well above or well below the eye level of any sitting or standing observers whenever possible
- The laser should be mounted firmly to assure that the beam travels only along its intended path
- Always use proper laser eye protection for the direct beam or a specular reflection
- Key switch to prevent tampering by unauthorized individuals
- Remove all unnecessary mirror-like surfaces from within the vicinity of the laser beam path

Class 4 - High Power, High risk of injury and can cause combustion of flammable materials.

- May also cause diffuse reflections that are eye hazards and may also cause serious skin injury from direct exposure

Safety Precautions

- Class 3B safety precautions and;
- Should only be operated within a localized enclosure or in a controlled workplace
- If complete local enclosure is not possible, Interlocking of room
- Eye wear is needed for all individuals working within the controlled area
- Backstops should be diffusely reflecting - fire resistant target materials

ANSI Z136.1 emphasizes that "It must be recognized that this classification scheme relates specifically to the laser device and its potential hazard, based on operating characteristics. However, the conditions under which the laser is used, the level of safety training of persons using the laser, and other environmental and personnel factors are important considerations in determining the full extent of safety control measures."

Appendix B

Protective Eyewear
The following factors shall be considered in selecting appropriate laser protective eyewear:

1. Laser power and/or pulse energy
2. Wavelength(s) of laser output
3. Potential for multi-wavelength operation
4. Need for prescription glasses
5. Comfort and fit
6. Strength of materials
7. Capability of the front surface to produce a hazardous specular reflection
8. Requirements for anti-fogging design or coatings

The optical density of laser protective eyewear at a specific wavelength shall be specified. Many lasers radiate at more than one wavelength, therefore eyewear designed to have an adequate optical density for a particular wavelength may have an inadequate optical density at another wavelength radiated by the same laser. This is especially true for lasers that are tunable over broad wavelength bands.

Below is a link to an on-line optical density calculator provided by the Laser Institute of America. This should be used as a guideline only. Contact Radiation Safety for additional assistance in selecting the appropriate eyewear for the particular laser(s) being used.

https://www.lia.org/evaluator/od.php

Please note that while the Radiation Safety Office will provide assistance where requested, it cannot recommend specific brands or companies of laser protective eyewear. It is recommended that prior to any purchase of personal protective equipment that the purchaser request specifications of the equipment to ensure appropriate protection with the hazard involved.