THE UNIVERSITY *of* NORTH TEXAS
HEALTH SCIENCE CENTER *at* FORT WORTH

Laser Safety

Table of Contents

LASER

The main goal of this section at the University of North Texas Health Science Center (UNTHSC) is to ensure the safe use of lasers by detecting risks, providing laser supervision, and providing safety training to laser users. To accomplish this goal, HSC adopted the American National Standard for the Safe Use of Lasers, ANSIZ136.1-1993 and 25 Tex. Admin. Code § 289.301, which is the accepted minimum standard for laser safety. Each department that uses Class 3b or Class 4 lasers must have a copy of the HSC Laser Safety Manual. The Radiation Safety Officer (RSO), Laser Safety Officer (LSO) or Environmental Health and Safety (EH&S) has ANSI 2136.1-1993 or a more recent edition that is relevant on hand.

The majority of lasers have the potential to harm eyes if someone looks directly into the beam or specular reflections. High-power laser beams can also ignite flammable objects, burn exposed skin, and activate toxic compounds, releasing dangerous fumes, gases, debris, and radiation. Hazards related to water, high voltage, high pressure, cryogenics, noise, radiation, and poisonous chemicals are also introduced by the machinery and optical gear needed to create the lasing action and control and steer the laser beam.

1.1 Responsibilities

1. The Laser Safety Officer

The responsibilities of the Laser Safety Officer (LSO) or representative will be but not limited to:

i). Keep track of each Class 3b and Class 4 laser's inventory. If necessary, classify or confirm classification.

ii). Be in charge of evaluating laser work area hazards, including the creation of Nominal Hazard Zones.

iii). Approve alignment methods, standard operating procedures, and other control measures.

iv). Offer advice on worker training programs, laser hazard evaluation, and laser hazard control.

v). Check the HSC Laser Safety Program's compliance with all Class 3b and Class 4 lasers at least once a year. Be sure to take any necessary corrective action.

vi). Without sufficient danger controls, stop using a laser or laser system and notify the Laser Safety Committee of your decision.

vii). Approve the language on equipment labels and area signs.

viii). Keep the records that different regulatory agencies require. Ensure that medical examination records are kept up to date and that training has been given.

ix). Look into cases when people may have been exposed to dangerous lasers.

2. Investigators and Supervisors

i). Monitoring lasers in the laboratories.

ii). Providing, putting into practice, and upholding the safety rules and guidelines outlined in this program.

iii). All of their lasers have been categorized and labeled.

iv). Sending the LSO a completed Laser Registration Form.

v). Teaching all users and those working around Class 3b and 4 lasers how to operate lasers safely. Documentation of this training is required.

vi). Enrolling in the Class 3b and Class 4 laser users' Medical Surveillance program, if possible.

vii). In the case that you are exposed to a Class 3b or Class 4 laser, you should notify the LSO right away.

3. Laser Operators

I). Observing the alignment, operation, safety, and maintenance SOPs for the laboratory.

ii). Reading the operating manuals for laser equipment for more safety advice.

iii). Letting the investigator or supervisor know right away if any defined safety measures are broken. This also applies to reporting an exposure incidence.

iv). Enrolling in the Class 3b and Class 4 laser users' Medical Surveillance program, if possible.

1.2 Personnel Training and Qualification

The Laser Safety Manual must be read and initial laser safety training must be completed by all staff and students using lasers.

A laser can only be used by someone qualified and authorized to do so. The Investigator or Supervisor uses departmental, technical, or other approved learning experiences to determine the employee's operational qualification. A person must do the following before using a Class 3b or Class 4 laser:

i) Read the Laser Safety Manual.

ii) Get a detailed rundown of the administrative, alignment, and standard operating procedures (SOPs) for the laser equipment to be used from the lab manager or principal investigator.

iii) Go over the manufacturer's operating and safety guidelines.

1.3 Medical Surveillance

A baseline eye test must be completed within two years of the intended laser use for laser operators and anyone who will operate in environments where they may be exposed to laser radiation from a Class 3b or Class 4 laser. Class 1, 2, and 3a laser operators are excused from having their eyes examined.

In the event of exposure or a suspected exposure incidence, an eye exam is necessary. Unless the worker has experienced a known laser injury to the eye, no examination is necessary when an individual laser user leaves their position at a laser laboratory.

1.4 Exposure Incident

If exposure occurs, the following steps must be taken:

i) The Principal Investigator (PI) or the person using the laser shall notify the LSO if an exposure occurrence takes place.

ii) If the incidence results in an injury or could have resulted in an injury, the individual or persons exposed should notify their supervisor and have an eye examination. If they so wish, the person may make an appointment with a doctor through the LSO.

iii) LSO will look into the occurrence, and a report will be created.

Maximum Permissible Exposure (MPE) is the amount of laser radiation to which a person can be subjected without risking harmful effects or causing harmful biological changes to their skin or eyes. In Section 8 of ANSI Z136.1-1993, the requirements for MPE for the eye and skin are described in depth.

1.5 Laser Hazard Analysis

Laser radiation threats must be recognized and assessed before suitable controls can be chosen and put into place.

Risk categories include:

a) Eye: Prolonged exposure to lasers with specific wavelengths and powers can result in corneal or retinal burns (or both). Chronically high amounts of exposure may harm the retina or develop lenticular or corneal opacities (cataracts).

b) Skin: Carcinogenesis may occur for ultraviolet and near-ultraviolet wavelengths, whereas acute exposure to high levels of optical radiation may result in skin burns.

c) Chemical: Some lasers require poisonous or dangerous materials to function (i.e., chemical dye, Excimer lasers).

d) Electric shock: The majority of lasers emit lethal high voltages.

e) Fire dangers: The dye lasers' solvents are combustible. ignition could be brought on by high voltage pulse or flash bulbs. Direct beams or specular reflections from high-power continuous wave (CW) infrared lasers have the potential to burn flammable materials.

f) Water Risks: Since most lasers use water cooling, flooding is a potential risk. Regular inspections of hose connections are advised.

According to their ability to cause harm, lasers and laser systems are grouped, and for each group, specific controls are then defined. The manufacturer categorizes and labels lasers produced after August 1, 1976. Class, maximum output power, pulse duration (if pulsed), and laser medium or emission wavelengths must all be listed on the label.

1.6 Laser Classification

Lasers are generally classified and regulated based on the following criteria:

Class 1: Low-power lasers and laser systems that cannot emit laser radiation levels greater than the Maximum Permissible Exposure (MPE). Class 1 lasers and laser systems are incapable of causing eye damage and are therefore exempt from any control measures.

Class 2: Visible, low-power lasers or laser systems that, unless viewed directly for an extended period of time (greater than 1000 seconds), are incapable of causing eye damage.

Class 3: Medium-power lasers and laser systems capable of causing eye damage with short duration (<0.25 s) exposures to the direct or specularly reflected beam. includes lasers of classes 3a and 3b.

- Class 3a: Lasers or laser systems that ordinarily pose no threat when briefly observed with the unaided eye. If seen through collecting optics, they might be dangerous.
- Class 3b: Lasers or laser systems that pose a threat when directly viewed. This includes specular reflections or intrabeam viewing.

Class 4: Extremely strong lasers and laser systems that can harm your eyes severely when exposed for just 0.25 seconds to the direct, specularly reflected, or diffusely reflected beam. Additionally, class 4 lasers and laser systems have the power to ignite combustible and flammable materials as well as severely harm the skin.

A Class 3b or Class 4 laser may not be used or energized on HSC property without a valid HSC Laser Permit.

1.7 Recommendations and Requirements for General Laser Safety

1. Eye Protection: It is the responsibility of the PIs or staff who operate or supervise the operation of a laser to determine the need for laser eye protection for a specific laser. If necessary, the supervisor will provide eye protection to staff and visitors to the area. The Laser Institute of America's booklet "Guide for Selection of Laser Eye Protection" may help with eyewear selection. For a copy, contact your PI or the LSO.
2. Always use the minimum laser radiant energy or laser power level required for the application.
3. Beam Control: To reduce direct eye exposure, take the following precautions:

a. Regardless of the power of the laser, do not look directly into it or at a specular reflection.

b. Bring the beam path to an end at the end of its useful path.

c . When standing or sitting at a desk, locate the beam path at a point other than eye level.

d. Position the laser so that the beam does not point toward any entry doors or aisles.

e. Reduce specular reflections.

f. Securely mount the laser system on a stable platform to keep the beam in place during operation and to limit beam traverse during adjustments.

g. Keep dangerous reflections and primary beams on the optical table.

h. Clearly identify beam paths and make sure they don't cross populated areas or traffic lanes.

i. If the beam path is not completely enclosed, position the laser system so that the beam is outside the normal eye-level range of 1.2 to 2 meters from the floor. Where the beam irradiance exceeds the MPE, a beam path exiting from a controlled area must be enclosed.

1.8 Additional Laser Class 1 and Class 2 Controls

Attach a label to the laser with its classification and relevant warning information if it has not been labeled by the manufacturer. For assistance, please contact the LSO.

Further guidance on control measures for various laser classifications can be found in ANSI Z136.1-1993.

1.9 Additional Laser Class 3b and 4 Controls

1. All PIs must write standard operating procedures (SOP) detailing alignment, operation, safety, and maintenance procedures for all laser operations involving Class 3b and Class 4 lasers. The SOP should be posted on the inside of the lab door or attached to it.
2. Other unusual operating conditions may necessitate additional procedures. For assistance, contact the LSO.
3. A log must be kept that details the periods of use, service, maintenance, and incidents. This log should also include required monthly interlock checks.
4. Labels: A laser classification label must be prominently displayed on the laser housing.

5. Warning Signs: In accordance with ANSI Z136.1-1993, each entrance must be marked with a danger sign.
6. Warning Devices: All laboratories with Class 4 lasers must have a lighted warning sign that is fail-safe interlocked with the laser and activates when the laser is turned on. The device must be tested on a monthly basis.
7. Class 4 Safety Interlocks
    a. All protective enclosures that surround laser devices and high-voltage electrical sources must also include interlocks to prevent the equipment from operating when the enclosures are not in place.
    b. Interlocks must be tested on a monthly basis to ensure they are operational. Each test must have a written record kept in the log book.
    c. Interlocks must be designed so that once activated, the capacitor banks, shutters, or power supplies can only be re-energized by manually resetting the system.
8. If all of the following conditions are met, the responsible individual in a laser area controlled by a warning light may temporarily override (bypass) interlocks to allow authorized persons access:

    a. There is no risk of laser radiation at the point of entry.

    b. Personnel entering the area are wearing the necessary protective equipment.

    c. The interlock control system includes an interlock bypass circuit.

    d. Only operate this bypass circuit from within the interlocked area. It must only wait 15 seconds before shutting down the system.

9. If interlocks are not possible, the Investigator or supervisor may consider using alarms, voice warnings, warning lights, door locks, key cards, or extensive security. When considering alternatives to interlocks, the LSO must be consulted.

10. Laser laboratories and controlled areas must be designed to allow personnel to enter and exit in an emergency.

11. Lasers must have a master switch with a key or coded access that prevents use once the key or code is removed. When the laser is not in use, the key must not be left in the control panel.

12. Laser Activation Warning Systems: During activation and startup, an alarm, a warning light, or a verbal "countdown" command must be used.

13. Lasers must have a fixed beam stop or attenuator as well as emission delays.

14. Laser controlled areas with limited access and sufficient shielding to contain or direct scattered radiation must be established. During laser operation, access to the area requires the permission of the responsible operator.

15. Infrared laser beams of class 3b and 4 with wavelengths greater than or equal to 710 nm must be terminated with fire-resistant material.

16. Firmly fasten all mirrors, prisms, beam stops, and other objects in the beam path. Make sure the laser is also securely fastened.

17. Each laser must have its own circuit breaker.

18. Beam Enclosure: For Class 4 lasers, the entire beam path, including the target area, should be surrounded by an enclosure equipped with interlocks that prevent the laser system from operating unless the enclosure is properly secured. When total enclosure of the laser beam path is not possible, both the non-enclosed laser beam and any strong reflections must be terminated at the end of their useful path using backstops, shields, or beam traps.

19. Control of Reflection

a. Wherever possible, materials that diffusely reflect laser radiation should be used instead of specularly reflective surfaces.

b. Specularly reflecting surfaces required for beam path control should be enclosed or shielded to reduce personnel exposure.

20. Invisible Beams

UV and infrared (IR) lasers that emit invisible beams necessitate several additional controls:

a. In areas where personnel may be exposed to radiation in excess of the MPE, visual or audible beam-warning devices must be installed. These warning devices must be clearly labeled and visible from all potential exposure areas.

b. Shielding must be installed to reduce UV radiation to levels lower than the MPE for the wavelength being used.

c. Dangerous concentrations of by-products formed by the reaction of intense UV radiation with nearby materials must be monitored.

d. IR beam enclosures and backstops must be fire-resistant and made of IR-absorbent material.

21. The Mapping of Beams

The user must survey controlled laser areas both initially and when beam path changes are made in order to locate and identify direct and reflected beams that exceed the MPE.
Shielding may be necessary to reduce unwanted radiation.

22. Direct Observation

Personnel should never stare directly into a laser beam.

23. Alignment

a. If the radiant exposure or irradiance exceeds the MPE, high power laser optical systems must never be aligned by direct beam viewing.

b. Use low-power lasers, diffuse reflectors, image-retaining screens, exposed Polaroid film, and other eye-protection devices.

24. Optical Viewing Aids

Using optical systems to view laser beams, such as cameras, telescopes, microscopes, and so on, may increase the eye hazard. As a result, all collecting optics must include appropriate means (such as interlocks, filters, or attenuators) to prevent eye exposures exceeding the MPE.

25. Personal Protection Equipment

a. Laser protective eyewear must be worn whenever MPE levels are likely to be exceeded. When using lasers, however, it is best to always wear eye protection.

b. In general, eyewear protects against a narrow range of laser wavelengths. Eyewear designed to protect against one wavelength may provide little or no protection against another.

c. For proper protective eyewear selection, consult eyewear manufacturers and the LSO. Laser protective eyewear must be American National Standards Institute (ANSI) approved and clearly labeled with the optical densities and wavelengths for which protection is provided. The user must inspect the eyewear on a regular basis for pitting and cracking of the attenuating material, as well as mechanical integrity and light leaks in the frame.

d. Skin protection can be obtained by wearing clothing that covers normally exposed skin areas.

e. Protective gear is no substitute for common sense and good safety practices.

26. Equipment Left Unattended

a. De-energize the power supplies or capacitor banks and remove the keys from power switches or master interlocks when leaving lasers unattended to prevent unauthorized equipment activation.

b. Unattended laser operation is only permitted when a specific SOP has been written and approved by the Principal Investigator and the LSO.

27. Left Unattended Equipment

a. When leaving lasers unattended, de-energize the power supplies or capacitor banks and remove the keys from power switches or master interlocks to prevent unauthorized activation of the equipment.

b. Unattended laser operation is permitted only if a specific SOP has been written and approved by the Principal Investigator and the LSO.

c. Restrict access to the area to those wearing proper protective equipment when the entire beam path is not fully enclosed. Check that all optical paths from the restricted access area are adequately covered to prevent laser radiation greater than the MPE for the eye from escaping.

28. For more information on control measures for various laser classifications, see ANSI Z136.1-1993 and Table 10 of this manual.

1.10 Converting to a Class 1 Enclosed Laser

1. Secured Housing

    a. Enclose the laser system in a protective enclosure to prevent laser radiation from escaping above the MPE.

    b. During normal operation, the protective housing must prevent personnel from accessing the laser system.

    c. Employees entering the enclosure for maintenance or adjustment must be made aware of the higher-risk laser class.

2. Safety Interlocks

    a. Install safety interlocks anywhere the protective enclosure can be opened, removed, or moved.

    b. When activated, these interlocks must stop a beam from leaving the laser or laser system that has radiant energy above the MPE.

    c. Service adjustments or maintenance work performed on the laser system must not render the interlocks inoperable or raise exposure levels outside the enclosure above the MPE, unless done in a laser area with limited access and appropriate safeguards, supervision, and control.

3. Fail-Safe Design: The laser system and protective enclosure must be built in such a way that, even in the event of a failure, they will still be able to meet the specifications for an enclosed laser operation.

4. Commercial laser system alterations must be assessed. Contact the LSO to request an assessment. An SOP will be necessary if the modifications reduce the safety controls.

5. Attenuated Viewing Windows: Utilize viewing windows with a suitable filter material that, under all operational circumstances, will attenuate the transmitted laser radiation to levels below the MPE.

6. Warning Labels and Signs

    a. Post warning signs reading "CAUTION-ENCLOSED LASER" on the enclosure.

b. If the enclosure is not present, affix a label directly to the laser that identifies it. Ensure that when the enclosure is opened, the label is visible right away.

1.11 Controlling Associated Hazards

In addition to laser radiation, the laser area contains numerous chemical and physical hazards that need to be properly controlled.

1. Electrical Systems and Equipment

a. Due to the presence of electrical power sources, laser operations carry a significant risk of injury and fire.

b. Electrical equipment and systems must be installed, used, and maintained in accordance with current regulations. Contact EH&S if you need help.

2. Light

In areas that are under control, adequate lighting is required.

b. If lights go out while using a laser, install a radio-controlled switch or place control switches in convenient spots.

c. Luminescent strips should be used to mark switch locations, aisles, and corners of tables and other equipment, among other things.

d. Install emergency lighting when natural light is insufficient to safely exit a laser area during an electrical power outage.

3. Ionizing and non-ionizing Radiation

a. Ionizing radiation that results from the use of electrical power greater than 15 kV may be present during a laser operation. A CAUTION-X-RAYS sign must be prominently displayed if X-rays are produced.

b. Laser systems or supporting hardware may produce microwave and radio frequency (RF) fields.

c. Prior to beginning an operation, get in touch with the radiation safety officer to get an assessment of these risks.

4. Hazardous Materials

a. Only bring hazardous materials required for the operation into the laser area.

b. It is necessary to use, store, and control all hazardous materials properly. Safety Data Sheets, additional EH&S safety plans, and EH&S can all be consulted for information.

c. Avoid exposing flammable substances, explosives, highly flammable liquids or gases, or substances that break down into highly toxic byproducts at high temperatures to laser beams and strong reflections without providing adequate controls.

d. Run tests to determine the effects of beam interactions with dangerous substances, or sponsor such tests. The results of tests can be used to establish safe laser operation parameters.

5. Dyes and Solutions

a. Complex fluorescent organic dye that has been dissolved in an organic solvent serves as the lasing medium for dye lasers in most cases. The toxicity, mutagenicity, and potential carcinogenicity of these dyes vary greatly.

b. All dyes need to be handled like dangerous chemicals. The majority of dye solution solvents are flammable and toxic when ingested or absorbed through the skin.

c. Obtain Safety Data Sheets for all dyes and solvents from the EH&S Office.

d. Follow the instructions on the Safety Data Sheets when using and storing all dyes and solvents.

e. Create and work with dye solutions in a fume hood.

f. Put on a lab coat, safety goggles, and gloves. Call the EH&S office for help choosing gloves.

g. Prior to using dye solutions, pressure-test all dye laser components. Particular focus should be given to tubing connections.

h. Put spill pans under reservoirs and pumps.

i. Watch out for contaminated components.

j. Keep the dye-mixing areas tidy.

6. Water

a. Since lasers are typically cooled by water, flooding is a possibility.

b. Regularly inspect the hose connections.