Laser Safety Program

Cleveland State University

Office of Environmental Health & Safety

Date : 12/2/2019

Table of Contents

1. Introduction page 3
2. Responsibilities Page 3-4
3. Laser Classification page 4-5
4. Laser Acquisition, transfer and disposal page 5
5. Control Measures page 5-8
6. Protective equipment page 8-9
7. Warning signs and equipment labels page 10-11
8. Training page 11
9. Medical Surveillance page 11
10. Non-beam hazards page 11
11. Laser accidents page 11
12. Record keeping page 12
13. Laser Safety Plan page 12-14
14. Laser Alignment Guidelines page 15
15. Standard Operation Procedure (blank) page 16-19

Introduction

Cleveland State university makes all reasonable efforts to:

1. Protect the health and safety of Cleveland State University (CSU) faculty, staff, and students.
2. Provide safe work practices- academic, research, and administrative for faculty, staff, and students.
3. Provide information to faculty, staff, and students about health and safety hazards.
4. Identify and correct health and safety hazards and encourage faculty, staff and students to report hazards.
5. Provide information and safeguards for those on campus and in the surrounding community regarding environmental hazards arising from operations at Cleveland State University.

To help fulfill the University Safety Policy: 3344-27-01 the Laser safety Program has been developed to provide guidance for the safe use of lasers and laser systems. Program and recommendations are based on The American National Standards Institute (ANSI) Z136-.1-2014 Standard for safe Use of Lasers.

Responsibilities

1. Laser Safety Officer (LSO)
    a. Program Development
    b. Classification
    c. Hazard Evaluation
    d. Provide laser safety training
    e. Provide ANSI warning signs and labels
    f. Periodically audit laser use locations
    g. Investigate laser accidents
    h. Maintain inventory of Class 3b and Class 4 laser and laser systems.
2. Principal Investigators (PI)/ Supervisors:
    a. Identify laser hazards present in the work area, implement appropriate hazard controls, and correct and identified unsafe conditions.
    b. Develop a Standard Operating Procedure for each 3b , 4 laser or laser system.
    c. Identify all authorized personnel who are eligible to operate or maintain a class 3b , class 4 laser or laser system.
    d. Provide job specific training for each laser user (includes physical hazards, health hazards, and emergency procedures)
    e. Ensure that laser users follow established safety procedures.
    f. Keep copies of all current SOP's, training, inspections.
    g. Maintain a current copy of the Laser safety Program.

3. Laser users:
    a. Know the hazards and precautionary procedures for laser use in the work area.
    b. Attend required training(s)
    c. Plan and conduct operations in accordance with established procedures and good safety practices.
    d. Use personal Protective equipment in accordance with prescribed training.

Laser classification

Lasers are divided into number of classes depending upon the power or energy of the beam and the wavelength of the emitted radiation. Laser classification is based on the laser's potential for causing immediate injury to the eye or skin and/or potential for causing fires from direct exposure to the beam or from reflections from diffuse reflective surfaces. A qualitative description of laser classes can be found below (ANSI Z136.1-2014).

Class 1 laser system:
Considered to be capable of producing exposure conditions during normal operation unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or telescope (collimated beam) and Exempt from any control measures other than to prevent potentially hazardous optically aided viewing; and is exempt from other forms of surveillance. Standard laser copiers , laser printers, optical scanners, or equivalent equipment will be assumed to be class 1 lasers enclosed in a protective housing and will be exempt from filing a Laser Safety Plan unless the user or office knows of any reason that the equipment would not be considered a class 1 laser. Laser pointers and similar low power devices do not require a laser safety plan. User of these low power systems shall read the safety precautions in the manufacturers literature and safety information posted on the Universities Laser Safety webpage.

Class 2 Laser system:
Emits radiation in the visible portion of the spectrum (0.4 to 0.7 µm), and Eye protection is normally afforded by the aversion response

Class 2M laser system:
Emits in the visible portion of the spectrum (0.4-0.7 µm) and
Eye protection is normally afforded by the aversion response for unaided viewing.
However, Class 2 M is potentially hazardous if viewed with certain optical aids.

Class 3 systems: (medium power)
May be hazardous under direct and specular reflection viewing conditions but is normally not a diffuse reflection or fire hazard.

There are two subclasses:

- A Class 3 R laser system is potentially hazardous under some direct and specular reflection viewing conditions if the eye is appropriately focused and stable, but that probability of an actual injury is small. The laser will not post either fire hazard or diffuse-reflection hazard.
- A Class 3B laser system may be hazardous under direct and specular reflection viewing conditions but is normally not a diffuse reflection or fire hazard.

Class 4 system: (high power)
Is a hazard to the eye or skin from the direct beam, and
May pose a diffuse reflection or fire hazard
May also produce laser generated air contaminants (LGAC) and hazardous plasma radiation.

Commercially produced lasers are classified according to the CDRH Federal Standard (FLPPS, 21 CFR 1040) and identified by labels affixed to the laser. Removal of protective housing or system modification can increase a laser's classification. Contact the LSO for review prior to servicing or system modification.

Laser Acquisition, Transfer and Disposal

Acquisition

All equipment must be purchased through the University's Purchasing Office.

Transfer:

The LSO must be notified when a Class 3b or 4 laser is transferred from the jurisdiction of one PI to another PI on-campus. The new PI/LSC must complete a Laser Registration form. A new laser identification tag will be provided. The LSO must also be notified if the laser is transferred off-campus.

Disposal

The LSO must be notified when a Class 3b or Class 7 laser is sold or disposed of and will coordinate with the Hazardous Waste Program, as appropriate.

Control Measures

When used as intended Class 1, 1M,2,2M, 3R laser systems are generally low hazard devices; however some requirements still apply.

1. As with any piece of equipment PIs/LSC are responsible for ensuring training on proper use of that equipment.
2. Exposure to laser radiation must be kept below the Maximum Permissible Exposure (MPE) under all conditions of operation or maintenance.

3. Laser systems must have the appropriate warning labels with the laser sunburst logotype symbol and the appropriate cautionary statement. See Section 7.0.
4. Removal of protective housing or system modification can increase a laser's classification. Contact the LSO for review prior to servicing or system modification.
5. Use of class 3R laser with telescopes, microscopes, or alignment devices should be reviewed by the LSO prior to operation.

Class 3B and Class 4 laser systems

A laser hazard analysis, including determination of the MPE and Nominal Hazard Zone (NHZ), must be made by the LSO. If it is determined that the classification associated with the maximum level of accessible radiation is Class 3b or 4, a laser-controlled area is established and control measures instituted. Control measures are only required within the NHZ.

Class 3B Control areas

1. Must be controlled to permit lasers and laser systems to be operated only by authorized personnel.
2. Must be posted with the appropriate warning sign(s). See Section 7.0.
3. All area or entryway safety controls must be designed to allow rapid egress by laser personnel and admittance to the laser-controlled area under emergency conditions.
4. Must be operated in a manner such that the laser beam path is well defined and projects into a controlled airspace when the laser beam must extend beyond an indoor controlled area, particularly to the outdoors under adverse atmospheric conditions, i.e. rain, fog, snow, etc.
5. Must be under the direct supervision of an individual knowledgeable in laser safety.
6. Must have all windows, doorways, open portals, etc. either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the applicable ocular MPE.
7. Must have only diffusely reflecting materials in or near the beam path where possible.
8. Must have appropriate personal protective equipment readily available (i.e., eye protection).

Class 4 laser control areas **must incorporate all Class 3b control measures plus the following:**

1. Control area interlocks or alternate controls to preclude the entry of unprotected personnel while Class 4 laser radiation is present in the control area. The interlock system may be designed to preclude entry while the laser is operating or to terminate laser operation when the door is opened without deliberate overriding of the interlock by a trained laser user.

   If the above measure is not feasible then a,b,c, must be done.

   a. Blocking barrier, screen, curtains, etc. must be used to block, screen, or attenuate the laser radiation levels so that the MPE is not exceeded at the entry point.
   b. At the entryway there must be a visible or audible signal indicating that the laser is energized and operating at Class 4 levels. A lighted laser warning sign or

flashing light (visible through protective eyewear) is acceptable entryway warning light alternatives.

c. Personnel trained on entryway procedures and adequate personal protective equipment provided upon entry.

Engineering Controls

The engineering control measures required for Class 3b and 4 lasers are listed below. Where specific engineering controls are infeasible they may be replaced with specific administrative and procedural controls and personal protective equipment (PPE) with prior review by the LSO. Alternative controls and PPE requirements must be documented in a written SOP. See Appendix G for additional explanation of each feature.

Engineering Controls √ =Required + =Recommended	**Laser Class** 3b	**Laser Class** 4
Protective Housing- for active laser work with housing off, contact LSO for hazard analysis and appropriate controls	√	√
Interlocks on Protective Housing	√	√
Service Access Panels Interlocked or tool required and appropriate warning label on the panel	√	√
Key Control	+	√
Remote Interlock Connector	+	√
Beam stop or attenuator	+	√
Laser Activation Warning System	+	√
Emission Delay		√
Remote Firing and Monitoring		+
Panic Button		√
Viewing windows, diffuse display screens, or collecting optics (lenses, Microscopes, ect.) are controlled with interlocks, filters, or attenuators to maintaine laser radiation at the viewing position at or below the applicable MPE	√	√
Enclosed Beam Path	+	+

Administrative and Procedural Controls

Administrative and procedural controls are methods or instructions that specify rules, or work practices, or both, which implement or supplement engineering controls. Necessary administrative and procedural controls for 3b and 4 laser and laser systems include, but are not limited to:

1 Standard Operating Procedures (SOPs) – written laser specific SOPs should be developed for Class 3b lasers and laser systems. Written SOPs are required for Class 4 lasers and

must include procedures for operation, maintenance, and other relevant safety considerations.

2. Authorized Personnel – PI/LSC must identify authorized personnel and ensure that those personnel are the only ones that operate maintain, or service a Class 3b or 4 laser or laser system. Laser Safety Training has been completed as well as on the job training and that PPE are provided before access to Class 3b and 4 laboratories are granted.
3. Alignment Procedures – ensure SOPs specify alignment procedures. See alignment guidelines.
4. Use minimum laser radiation required for the application. If necessary, the LSO may require the reduction of levels of accessible power or radiant energy during the operation or maintenance of a Class 3b or Class 4 laser system.
5. Lasers or laser systems must have the appropriate warning labels. See Section 7.0 for warning label requirements.
6. Maintain beam height at a level other than the normal position of the eye of a person in the standing or seated position.

Protective Equipment

Personal protective equipment may have serious limitations and must be used only in conjunction with engineering and administrative controls, when working with Class 3b and Class 4 lasers and laser systems.

Eye Protection

Appropriate eye protection devices must be worn when working with Class 3b and Class 4 lasers or laser systems. Laser protective eyewear is usually not required for Class 2 of Class 3a lasers or laser systems, except in conditions where intentional long-term (>0.25 seconds) direct viewing is required. Eyewear must be specifically selected to withstand either direct or diffusely scattered beams and shall meet all provisions of ANSI Z87.1-1989. (4.6.2.3)

Eyewear must be inspected before each use, and replaced if necessary, to maintain the eyewear in good condition. Contact the LSO for assistance in selecting protective eyewear.

Factors in selecting appropriate eyewear:

1 Laser power and/or pulse energy
2 Wavelength(s) of laser output
3 Potential for multi-wavelength operation
4 Radiant exposure or irradiance levels for which protection (worst case) is required
5 Exposure time duration (4.4.4.2.3.2)
6 Maximum permissible exposure
7 Optical density requirement of eyewear filters at laser output wavelength(s)
8 Angular dependence of protection afforded (4.4.4.2.9.3)

9 Visible light transmission(VLT) requirement and assessment of the effect of the eyewear on the ability to perform tasks while wearing the eyewear. When VLT is less than 20%, there may be insufficient light to preform the intended task.
10 Need for side-shield protection and maximum peripheral vision.
11 Radiant exposure or irradiance and the corresponding time factors at which laser safety filter characteristics degradation occurs, including transient bleaching (4.4.4.2.9.2) especially for ultra short pulse lengths
12 Prescription glasses
13 Comfort and fit
14 Degradation of filter media, (bleaching)
15 Strength of materials (resistance to mechanical damage and shock ANSI Z87.1)
16 Capability of the front surface to produce a hazardous specular reflection
17 Anti-fogging or coatings

Skin Protection

Skin protection can best be achieved through engineering controls. If potential skin damaging exposures exist, skin covers and or “sun screen” creams are recommended.

Minimize exposure to UV radiation by using beam shields and clothing (opaque gloves, tightly woven fabrics, laboratory jacket or coat) which attenuate the radiation to levels below the MPE for specific UV wavelengths. Consider flame retardant materials for Class 4 lasers

Special attention must be given to the possibility of producing undesirable reactions in the presence of UV radiation (formation of skin sensitizing agents, ozone, LGAC etc.).

Window protection, barriers and curtains

Exterior or interior windows that are located within the NHZ of a Class 3b or Class 4 laser of laser system must be provided with appropriate absorbing filter, scattering filter, blocking barrier, curtains or screen to reduce any transmitted laser radiation to levels below the applicable MPE level. Important factors for selection include:

1. ability to withstand direct and diffusely scattered beams,
2. flammability and decomposition products of the window material.

Warning Signs and Equipment Labels

approved signs and labels are recommended by the LSO and must be conspicuously displayed in locations where they best serve to warn onlookers. Personnel who do not read/understand the English language and who may need to enter areas where lasers are used, must be provided appropriate instructions as to the meaning of warning signs and labels. The PI/LSC is responsible for identifying and training such personnel.

Warning signs

Laser controlled area must identify the appropriate warning sign(s) at the entryway and if necessary, within the laser-controlled area.

- Danger: Must be used with all class 4 lasers and laser systems that exceed the appropriate MPE for irradiance. This signal word is restricted to class 4 laser with high (multi-kilowatt) output power or pulse energies with exposed beams.
- Warning: must be used on Class 3B and class 4 lasers or laser systems that exceed the applicable MPE for irradiance.
- Caution: Must be used with all signs and labels associated with class 2 laser and laser systems, and all class 3r lasers and laser systems that do not exceed the MPE for irradiance.

Equipment label

All lasers or laser systems (except Class 1) must have appropriate warning labels affixed to a conspicuous place on both the housing and the control panel (if separated by more than 2 meters).

Class 2 lasers and laser systems, “Laser Radiation – Do Not Stare into Beam”

Class 3r lasers and laser systems (accessible irradiance does not exceed MPE based upon 0.25 second exposure for wavelengths between 0.4 and 0.7 um), “Laser Radiation – Do Not Stare into Beam or View Directly with Optical Instruments”

All other Class 3r lasers or laser systems, “Laser Radiation – Avoid Direct Eye Exposure”

Class 3b lasers or laser systems, “Laser Radiation – Avoid Direct Exposure to Beam”
Class 4 lasers or laser systems, “Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation”

Labeling of Protective Eyewear
All eyewear must be clearly labeled with the optical density and wavelength. Color-coding or other distinctive identification is recommended in multi-laser environments.

Labeling of Laser Protective Windows and Collecting Optic Filters

All laser protective windows must be labeled with the optical density and wavelength(s) for which protection is afforded and should be labeled with the threshold limit and exposure time for which the limit applies, and the conditions under which protection if afforded.

Labeling of laser Protective Barriers
Will be labeled with the barrier's threshold limit and exposure time for which the time applies.

Training

PIs/LSC are responsible for ensuring that staff and students receive appropriate training on the hazards in their work area and that documentation of that training is maintained. Before operating a Class 3b or Class 4 laser or laser system, all users must:

1. Read the Laser Safety Program
2. Receive Laser safety training
3. Receive laboratory specific training
4. Read and acknowledge the appropriate SOP

Laser users must be retained whenever a new hazard is introduced into the work area.

Medical Examinations

Medical examinations shall be performed as soon as practical (within 48hours) when a suspected injury or adverse effect from a laser exposure occurs. For injury to the eye from laser operating in the retinal hazard region examinations shall be performed by an ophthalmologist.

Non-Beam Hazards

Non-Beam Hazards (NHB) are all hazards arising from the presence of a laser system, excluding direct exposure of the eyes or skin to a laser system. NBH include physical, chemical, and Biological agents. NBH may occur when a material is exposed to a laser beam (fire, airborne contaminates) , when materials used to generate the beam are released into the atmosphere , or when individuals come into contact with system components.

Laser accidents

All accidents /exposures are to be reported to the supervisor as soon as possible. Complete the CSU Occupational Injury and Illness form. This is located on the CSU Human resources webpage or on the Environmental Health and Safety webpage.

Record Keeping

The PI/LSC is responsible for maintaining all laser safety-related records (i.e., laser safety training, SOPs, inspections/ audits, medical surveillance) for each employee for a minimum of one year

Laser Safety Plan

A Laser Safety Plan (LSP) is a means for documenting the assessment of the hazards associated with the laser system and its use. The person responsible for the laser system is responsible for completing a hazard analysis and implementing measures to control hazards to levels permitted in ANSI Z136.1-2000. The LSP is submitted to the LSO for approval prior to beginning operation of the system.

The LSP consists of a description of the laser system, and a Standard Operating Procedure (SOP) which is a description of the operations involving laser use, a description of the laser radiation hazard zone(s) and other hazards (such as electrical or toxic materials) associated with the laser system, and the physical and procedural control measures that have been implemented to limit the hazards.

The Laser Safety Plan should be kept current and resubmitted for approval when significant modifications are made.

Cleveland State University Laser Safety Plan

Office of Environmental Health & Safety

Class 3b and Class 4 Laser

For the Operation of…(Give a brief description of laser or laser system including classification to be acquired):

_____

_____

_____

_____

Laser classification:
For additional information and guidelines, refer to the CSU's Guidelines for Laser Safety
Please provide the names and contact information (address, phone and email) other university officials responsible for the operation of the laser system.

1. Provide a summary of technical specifications for the laser system and a brief description of the work to be preformed with the laser (include a copy of the vendor's specifications and classification)
    a. Wavelength(s)
    b. Continuous wave Yes_____ No_____
    c. Pulsed? Yes_____ No_____
    d. Maximum Power _____
2. Describe the Facility/environment in which the laser or laser system will be used:
    a. Research Laboratory Yes_____ No_____
    b. Teaching Laboratory Yes_____ No_____
    c. Medical/surgical lab Yes_____ No_____
    d. Office/other Yes_____ No_____
3. Attach a Standard Operating Procedure (SOP) for general operation including identification of beam hazards, other hazards related to the systems operation; include maintenance and service procedures if not performed by manufacturers representatives. Describe the precautions taken to prevent exposure of personnel to levels above the MPE (ANSI Z136.1). Describe qualifications, training requirements for all personnel including students and observers._____
    _____
    _____
    _____
4. Will operation of this Laser or laser system involve the presence or any exposure to the general public at any time (such a special lab tours) or any unusual circumstanced?
    Yes_____ No_____ if Yes, please describe.
    _____
    _____
    _____

5. Will operation of this laser or laser system involve using lasers for Health care, Medical , Or surgical applications to animals or human patients? Yes_____ No_____
   If yes , Please indicate what institutional reviews (IACUC, IRB) are required /obtained, and include the procedures(s) for which the laser will be used in the SOP.

   Signatures:
   Faculty Member:_____
   Department Chair:_____

TO BE COMPLETED BY LASER SAFETY OFFICER

Plan Number _____

LSO Action

Approved

Approved with Provisions (see comments)

Deferred for Revision (see comments)

Disapproved

Comments:_____
_____
_____
_____

Laser Safety Officer

Signature:_____ Date:_____

Laser Alignment Guidelines

1.Exclude unnecessary personnel from the laser area during alignment.
2.Use low-power visible lasers for path simulation of higher power visible or invisible lasers whenever possible.
3.Wear laser protective eyewear during alignment. Use special alignment eyewear when circumstances (e.g. wavelength, power, etc.) permit their use.
4.When aligning invisible (e.g. UV, IR) beams, use beam display devices such as image converter viewers or phosphor cards to locate beams.
5.Perform alignment tasks using high-power lasers at the lowest possible power level.
6.Use a shutter or beam block to block high-power beams at their source except when actually needed during the alignment process.
7.Use a laser rated beam block to terminate high-power beams downstream of the optics being aligned.
8.Use beam blocks and/or laser protective barriers in conditions where alignment beams could stray into areas with uninvolved personnel.
9.Place beam blocks behind optics (e.g.: turning mirrors) to terminate beams that might miss mirrors during alignment.
10.Locate and block all stray reflections before proceeding to the next optical component or section.
11.Be sure all beams and reflections are properly terminated before high-power operation.
12.Post appropriate area warning signs during alignment procedures where lasers are normally Class 1 (enclosed).
13.Alignments should be done only by those who have received laser safety training.

STANDARD OPERATING PROCEDURES (SOP)
FOR CLASS 3B AND CLASS 4 LASERS USERS

1. GENERAL INFORMATION

A. Title: _____

B. Location of Work : Bldg _____ Room: _____

C. College: _____

D. Laser Safety Contact:_____

2. DESCRIPTION OF ACTIVITY:

A. Description of Activity including unique equipment (its application) or activity and principal parameters

B. Duration: on going _____, limited period _____months

3. IDENTIFICATION OF HAZARDS

Identification of potential hazards associated with the activity, lasers, and any additional hazards (i.e., toxic gases).

_____

_____

4. MITIGATION OF HAZARDS

Controls to reduce the potential hazards. From a laser perspective, the following needs to addressed

A. Identification of laser(s): Laser specifications

Complete chart (as much as possible), list all lasers, including low power alignment lasers

LASER 1, LASER 2, LASER 3, LASER 4

Type: _____

Manufacturer: _____

Model: _____

Serial #: _____

Max. Power: _____

Wavelength: _____

Wavelength used: _____

Power used: _____

Pulse Length: _____

Pulse Repetition Rate: _____

Beam Diameter:_____

Beam Divergence: _____

Property #: _____

Made in House: _____

Class: _____

B. Laser Users:_____

Only those personnel listed below are authorized to use the laser system unsupervised. They have attended the UH laser safety class. Users are responsible for assuring access control policies are followed. Signatures below indicate receipt of training on the specifics of this SOP.

Names	Date of laser safety training	Date of eye Exam	Signature

C. Attach a diagram of laser use area. (Simple block diagram will do, should also be posted on lab, door).

D. Describe access controls, including use of interlocks

It is the responsibility of the user to maintain and enforce access control.

E. Describe alignment procedures

All laser users need to keep in mind that the majority of laser accidents occur while aligning the laser. All possible steps will be taken to prevent any such accidents. Alignment procedures are performed in accordance to the manufacturer and at the lowest possible laser output, such that the primary beam or a specular reflection of

the primary beam does not expose the eye to a level above the maximum permissible exposure for intrabeam exposure. Safety laser glasses are worn at all times during alignment procedures. The laser beam is never to viewed directly. As a precaution, reflective jewelry will be taken off by those handling the laser.

F. Where have the laser warning signs been posted?

Laser warning signs indicate the lasers in the control area, maximum power output, wavelength and hazard class in use in the area. (Warning signs can be obtained from LSO)

G. Laser protective eye wear:

Has eyewear been selected?

The number that will be/are on hand: _____

Manufacturer	Optical Density	Wavelength

H. Beam Path:

Is beam path open, enclosed, or partially enclosed? Please explain.

_____

_____

I. Non-beam hazards, if any. List and describe how they have been addressed._____

_____

_____

MAINTENANCE -- The equipment will be maintained by specially trained and/or certified laboratory personnel. All relief devices, safety interlocks, alarms, and other hazard prevention devices will be maintained, calibrated, and tested for functionality on a regular basis in accordance with standard practices and recommendations of the manufacturer.

EMERGENCY PROCEDURES -- Authorized laser users will be familiar with the building Emergency Plan, location of emergency equipment, and emergency procedures for fires,

earthquakes and evacuations. Emergency shut off procedures for lasers consist of shutting off the electrical power to the laser system. The location of main electrical shut off switches to the laser must be posted on the exits.

ANNUAL REVIEW SCHEDULE -- Annual reviews will be one year from approval date. If new hazards have been introduced, a full RSP review will be required. Please send an update of the user's list to the LSO.