

Laser Safety Program Manual

Environmental Health and Safety
University of Maryland, Baltimore

Introduction

The University of Maryland, Baltimore (UMB) Laser Safety Program Manual sets forth controls and safety guidance for research and educational activities involving lasers. This program is established to institute prudent safety practices and to meet the requirements of OSHA 29 CFR 1926.54 and 1926.102.

This program is based on the guidance documents available from the American National Standards Institute (ANSI) Z136.1–2000 Safe Use of Lasers and ANSI Z136.3–1996 Safe Use of Lasers in Health Care Facilities.

These and other publications and services can be ordered through Laser Institute of America, www.laserinstitute.org.

1.0 Organization

The University Laser Safety Officer (LSO) within Environmental Health and Safety (EHS) shall administer the Laser Safety Program.

The Radiation Safety Committee (RSC) is a peer review committee with two members appointed who are laser users. The RSC advises University Administration and provides guidance regarding the Laser Safety Program. The RSC also considers appeals made by the laser users.

2.0 Laser Safety Officer (University LSO) (ANSI Z136.1, 4.2)

The University Laser Safety Officer (LSO) is an EHS staff member who has the knowledge and responsibility to apply appropriate laser radiation protection rules, standards, and practices. The University LSO is named and specifically authorized to perform duties specified in this Laser Safety Program Manual.

3.0 Classifications and Registration

Classification of lasers shall be in accordance with ANSI Z136.1. Each Class 3b or 4 laser at the University shall be registered, and shall have an Authorization issued by the University LSO. Arrays of semiconductor lasers shall be authorized if the

cumulative power exceeds Class 3a limits. Lasers which are classified as 3a or lower, but which contain a 3b or 4 lasers, shall be controlled at the higher classification if the class 3b or 4 lasers are accessible. Each Authorized User shall be responsible for establishing and supporting laser safety for the authorized laser.

3.1 Registration Information

Each laser that is possessed, purchased, donated, manufactured, created, assembled or otherwise received by any person or entity at the University shall be listed under an Authorization. [Application for the Authorization shall be tendered to the University LSO by the receiving party as soon as is practicable, but in no case more than 10 days following receipt of the laser.]

Additional information on laser registration is provided as Appendix 3 to this document. This section describes what information must be provided with the Laser Authorization Application. Information shall include:

1. The name and position of the applying Authorized User including, department and contact information.
2. The Laboratory Laser Safety Supervisor (LSS), if different from the Authorized User.
3. The signature of the Department Head or equivalent. The department head must recognize and acknowledge use of lasers in that department.
4. The physical location of the laser. This is the room number or lab. A drawing may be required in some instances.
5. The type of laser (Dye, Argon, Diode, Excimer, etc.)
6. The manufacturer of the laser. (From the control panel. If the laser is manufactured by University personnel, so state).
7. The model and serial number of the laser. (This should come from the control panel.)
8. The inventory number.
9. The excitation mechanism (Optical, electrical, chemical, etc.).
10. The time-dependent operating properties of the laser (CW, Pulse, Repetitively Pulsed, mode-locked, etc.).
11. If continuous wave (CW), the power in watts.

12. If pulsed:

- a. The maximum capable energy level of the laser in joules.
- b. The maximum pulse frequency per second.
- c. The minimum pulse duration.

13. The operating wavelength(s) of the laser.

14. Other information should include a brief description of the purpose of the laser (Doppler measurements, fluorescence etc.), frequency of use, expected primary users etc. Anything that may have a bearing on safety related issues.

Any request for exemption or waiver of these information requirements shall be addressed by the University LSO on a case-by-case basis upon petition from the person who possesses the laser. Multiple semiconductor lasers may be registered as an array if so designed. Class 3b or 4 semiconductor lasers must be individually listed on an authorization, and a means for tracking these lasers must be provided by the Authorized User.

3.2 Removal from Registration

Each laser that is rendered permanently inoperative by disassembly or destruction, or which is removed from the University's control by gift, surplus designation, or transfer to a non-University entity shall provide information regarding the condition or destination to the University LSO not later than 10 days from its inoperative state or removal. The Authorized User shall provide disposition information to the University LSO prior to the equipment leaving the University.

3.3 Manufacture/Construction

Each laser which is manufactured from components for formal transfer to an entity outside the University shall meet US Food and Drug Administration requirements per 21 CFR Part 1040, Federal Laser Product Performance Standard. A laser which is manufactured or assembled for internal University use, or which is designed for specific temporary use by another entity with express intent to return the laser directly to that entity is exempt from this requirement.

4.0 Laboratory Personnel (ANSI Z136.1, 4.4.4)

This section designates the responsibilities of the personnel working with lasers.

4.1 Authorized User

The Authorized User is the person whose name appears on the Authorization for the laser. Typically, this is the Principal Investigator and, must be permanent faculty or staff (not a postdoctoral fellow or a graduate student).

The Authorized User is responsible for:

1. Registering lasers with the University LSO.
2. Ensuring the availability of correct personal protective equipment (PPE). (See Appendix 5)
3. Preparing a Laser Safety Standard Operating Procedure (SOP) for Class 3b and/or Class 4 lasers. (See Appendix 5)
4. Providing, implementing, and enforcing the Laser Safety Program specific to the laboratory's laser.
5. Ensuring proper training in laser operation and safety.
6. Classifying and labeling all lasers in the laboratory.
7. Notifying the University LSO immediately if an exposure incident occurs.
8. Notifying the University LSO if a laser is decommissioned, sold, or transferred.

The Authorized User may designate any of these responsibilities to a Laboratory Laser Safety Supervisor, but ultimately the responsibility for these requirements rests with the Authorized User.

4.2 Laser Safety Supervisor

Each Authorized User shall designate a Laboratory Laser Safety Supervisor (LSS) and shall identify the Laboratory LSS to the University LSO. This person may be the Authorized User or a delegate, but shall be a budgeted employee (staff or faculty, not a graduate student or post-doctoral worker) of the University. (Normally the Authorized User retains the function and title of the Laboratory LSS.) The Laboratory LSS shall maintain the Laser Safety Program for the individual lasers in the laboratory, and may call on the University LSO for assistance as needed. The Laboratory LSS, acting under the Authorized Users authority has the responsibility to institute corrective actions including shutdown of laser operations when necessary due to unsafe conditions. Users will always report problems to the Laboratory LSS who will know which issues must be passed on to the University LSO.

4.3 Laser Operators or User

The laser operator or user is a person who sets up, aligns, operates or, uses the laser for experimental or research purposes, or has other assigned laser duties. The laser operator/user is responsible for:

1. Obtaining proper training prior to operating a laser.
2. Wearing all necessary PPE as designated by the Laboratory LSS.
3. Inspecting eyewear (prior to use) to ensure good condition.
4. Following laboratory administrative, alignment, safety, and standard operating procedures while operating the laser.
5. Keeping the Laboratory LSS fully informed of any departure from established safety procedures.

4.4 Service Personnel (ANSI Z136.1, 4.4.7)

Class 3b or 4 lasers shall only be serviced by authorized personnel approved by the laser manufacturer or by the LSO. University manufactured lasers shall only be serviced by individuals approved by the LSO.

4.5 Visitors (ANSI Z136.1, 4.4.6)

Visitors should not be allowed in a laser controlled area that contains a class 3b or 4 laser unless the Authorized User or Laboratory LSS have given approval, the degree of hazard has been explained, and appropriate protective measures are taken.

5.0 Maximum Permissible Exposure (MPE) and Nominal Hazard Zone (NHZ) (ANSI Z136.1, 3.4.1, 8)

MPE is the level of laser exposure to which the eye or (less limiting) the skin may be exposed without adverse affects.

NHZ is the space within which the level of direct, reflected or scattered radiation during operation exceeds the applicable MPE.

In most cases when any class 3b or 4 laser is used at levels at or above 3b in an open beam mode (unenclosed) the MPE will be assumed to be exceeded in that room or area and appropriate precautions shall be taken. In this case, the NHZ (nominal hazard zone) will be assumed to comprise the enclosure (room or area to which the beam is restricted to by virtue of walls, curtains or other barriers) in which

the laser is operating if operated at or above 3b levels. This is done to account for intentional or unintentional scattered or reflected beam.

In some circumstances the operation of lasers without a complete enclosure may be necessary. The NHZ does not necessarily apply to the whole area if the beam is confined by design to significantly limit the degree of accessibility to the open beam in some manner. In such situations, a hazard analysis should be performed to define the area where laser radiation is accessible at levels higher than the MPE. This analysis will determine the zone requiring control measures.

6.0 Required Laser Safety Program Features

6.1 Laser Safety Standard Operating Procedure *(ANSI Z136.1, 4.4.1)*

Each laser shall have a Laser Safety Standard Operating Procedure (SOP) written for its operation. An SOP is the same as a laboratory/laser/research specific protocol that specifies safe use and procedures for the laser system. The SOP must be present at the operating console or control panel of the laser. The SOP shall include at a minimum operating instructions, safety eyewear parameters and instructions for proper use, interlock instructions, and a checklist for operation. The SOP shall include clear warnings to avoid possible exposure to laser and collateral radiation in excess of the MPE. The SOP shall be available for inspection by the University LSO at any time. A template for Laser Safety Standard Operating Procedures is attached in Appendix 5.

6.2 Posting and Labeling *(ANSI Z136.1, 4.3.9, 4.3.14, 4.7)*

All laser equipment shall be labeled in accordance with ANSI Z136.1, 4.3.14 or the Federal Laser Product Performance Standard (FLPPS).

Areas that contain class 3b or 4 lasers shall be posted at all entryways using posting designated as appropriate to the laser by the LSO.

6.3 Safety Interlocks and Warning Systems *(ANSI Z136.1, 4.3.1)*

A safety interlock is a device that automatically prevents human access when exposure exceeds MPE limits.

Safety interlocks shall be provided for any portion of the protective housing that by design can be removed or displaced without the use of tools during normal operation or maintenance, and thereby allows access to radiation above MPE limits.

Adjustment during operation, service, testing, or maintenance of a laser containing interlocks shall not cause the interlocks to become inoperative except where a laser controlled area is established.

For pulsed lasers, interlocks shall be designed to prevent firing of the laser; for example, by dumping the stored energy into a dummy load and for CW lasers, the interlocks shall turn off the power supply or interrupt the beam (i.e., by means of shutters).

Each class 3b or 4 laser system shall provide visual or audible indication during the emission of accessible laser radiation. The indication shall occur prior to emission of radiation with sufficient time to allow appropriate action to avoid exposure. Any visual indication (e.g., lights) shall be visible through protective eyewear for the wavelength of the laser so that eyewear need not be removed to see it.

6.4 Safety Interlocks-Alternatives

The regulations recognize that in situations where an engineering control (automatic safety interlock) may be inappropriate, the University LSO shall specify alternate controls to obtain equivalent laser safety protection. Requests to use alternate controls may be submitted in writing to the University LSO and, if accepted, will be documented in the SOP.

Where safety latches or interlocks are not feasible or are inappropriate, a laser controlled area shall be established and the following shall apply:

1. All authorized personnel shall be trained in laser safety and appropriate personal protective equipment shall be provided and worn upon entry.
2. A door, blocking barrier, screen, or curtains shall be used to block, screen, or attenuate the laser radiation at the entryway. The level at the exterior of these devices shall not exceed the applicable MPE, nor shall personnel experience any exposure above the MPE immediately upon entry.
3. If a laser is energized and operating at class IV levels then at the entryway there shall be a visible or audible signal and other appropriate signage indicating laser operations. This indicator may be interfaced with the laser itself, the power supply, or manually operated in accordance with the SOP requiring its use.
 - a. For indoor laser controlled areas, during tests requiring continuous operation, the individual in charge of the controlled area may momentarily override the safety interlock. The sole purpose is to allow access to other authorized persons if it is clearly evident that there is no optical hazard at the entry area and protective eyewear is worn by the entering person.
 - b. For outdoor controlled areas (such as atmospheric tests) the Authorized User or Laboratory LSS must contact the Federal Aviation Administration or other appropriate agencies as necessary and must notify the University

LSO or Director of EHS three working days prior to operation of class IV levels of laser energy.

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

6.5 Key Control (ANSI Z136.1, 4.3.4)

All Class 3b and 4 lasers shall be provided with a master switch. The master switch shall terminate the beam and shall be operated by a key or coded access. Authority for access to the master switch shall be vested with the Authorized User or designated Laboratory LSS.

When lasers are left unattended, the master switch shall be left in a disabled condition. The operation of unattended lasers is only allowed when a specific SOP has been written and approved by the LSO.

6.6 Training (ANSI Z136.1, 4.4.3)

Every person who operates or works with Class 3b or 4 lasers shall complete training in laser safety provided by the University or University LSO-approved equivalent. This training is referred to as General Laser Safety Training. Persons completing General Laser Safety Training shall also complete specific laser safety training given by the Authorized User or Laboratory LSS for the lasers to which the individual will be exposed. No person may work in a NHZ prior to completing both laser safety-training classes.

6.7 Personal Protective Equipment (ANSI Z136.1, 4.6)

6.7.1 Protective Eyewear

Each Authorized User shall provide protective eyewear that meets the requirements of ANSI Z136.1, 4.6.2. The eyewear shall be located where persons who operate the laser have unrestricted access to the eyewear. The eyewear shall be worn during any operation where Class 3b or 4 beams are not enclosed. This normally includes alignments. Training on identification, proper fit, location, and use of eyewear shall be included in the specific laser safety training.

Protective eyewear shall meet the following requirements:

1. Provide a comfortable and appropriate fit all around the area of the eye.
2. Be in good physical condition to ensure the lenses retain all protective properties during its use.

3. Be of optical density adequate for the laser energy involved.
4. Have the optical density or densities and associated wavelengths permanently labeled on the filters or eyewear.
5. Be examined at intervals not less than 12 months, to ensure the reliability of the protective filters and integrity of the holders. Unreliable eyewear shall be discarded and replaced.
6. The optical density of the protective eyewear shall be appropriate for the specific frequency and pulse length of the laser beam in use, and shall provide reduction of the incident energy to less than the MPE of the laser. It is important to include the pulse length and frequency of pulse repetition of pulsed lasers in selecting appropriate protective eyewear.

6.7.2 Facility Window Protection (ANSI Z136.1, 4.6.3)

Facility windows located within the NHZ of class 3b or 4 lasers shall be provided with an appropriate filter or screen that reduces any transmitted laser radiation to levels below the applicable MPE level.

6.7.3 Laser Protective Barriers and Equipment (ANSI Z136.1, 4.6.4)

A blocking barrier shall be used in the laser controlled area of class 3b and 4 lasers to prevent the laser light from exiting the area at levels exceeding the applicable MPE level. Such laser barriers shall be selected to withstand direct and diffusely scattered beams. It is also important that the barrier not support combustion or release toxic fumes following laser exposure.

6.7.4 Skin Protection (ANSI Z136.1, 4.6.6)

When there is potential for skin exposure to levels exceeding the skin MPE for the laser, persons in the controlled area shall wear appropriate clothing, gloves, and/or shields.

6.8 Miscellaneous Safety and Training Issues

1. Persons working in a laboratory with multiple lasers shall be made aware of the various wavelengths and other operating parameters by the laser operator/users.
2. Persons working with tunable lasers, or any laser that is frequency doubled or frequency tripled, shall be aware of the effect of frequency manipulation and shall choose protective eyewear that will provide protection for the effective wavelength of the laser.

6.9 Surveys

Each Laboratory LSS shall survey the laboratory containing the laser(s) for which the Authorized User is responsible. The survey shall be performed using the form included in Appendix 4 or an equivalent that covers the same items at a minimum. The survey shall be performed at least quarterly, and shall be performed prior to operating a laser for the first time after assembly, maintenance, or modification of the beam path, operating wavelength, or power level. Survey records shall be retained for inspection by the University LSO.

6.10 Fiber Optic Transmission

Optical cables used for transmission of laser radiation shall be considered part of the laser protective housing. Disconnection of a fiber optic connector that results in access to radiation in excess of the MPE, shall take place in a laser controlled area. All connectors shall bear appropriate labels. Optical cables shall be encased in an opaque sleeve to prevent leakage of laser radiation in case of breakage. Note: If the fiber is designed to emit light through the walls of the fiber the Laboratory LSS must inform the University LSO and include justification for lack of opaque cover in the SOP.

6.11 Magnification of Laser Beam

If at any time a laser beam is optically magnified or concentrated, special precautions shall be taken by the Authorized User to prevent specular or diffuse reflection or other exposure greater than the MPE for the laser. The special precautions shall be documented in the SOP for the laser.

7.0 Records

Records of Surveys, Training, NHZ and MPE calculations, and other laboratory-specific information shall be maintained in the laboratory, and shall be available for inspection/review by the University LSO at any time. Records shall be maintained for a period of not less than 5 years.

8.0 Non-Radiation Hazards (*ANSI Z136.1, 7.0*)

Each Laboratory LSS shall evaluate or have an evaluation made of non-radiation hazards. This evaluation shall include electrocution, chemical, cutting edge, compressed gases, noise, confined space, fire, explosion, ventilation, and physical safety hazards. The evaluation shall be made part of the SOPs and be available for review.

8.1 Laser Dyes and Solvents (ANSI Z136.1, 7.8)

Laser dyes are complex fluorescent organic compounds dissolved in an organic solvent. Certain dyes are highly toxic or carcinogenic. Since these dyes must be changed frequently, special care must be taken when handling, preparing solutions and operating dye lasers. Laser dyes are subject to the University's Chemical Hygiene Plan and, if applicable, Flammable Liquid Storage policies. An MSDS for dye compounds shall be available to all appropriate workers.

9.0 Incident Reporting

Each Authorized User shall immediately seek appropriate medical attention for the injured individual and notify the University LSO by telephone of any exposure injury involving a laser possessed by the University.

The University LSO shall be notified within 48 hours of any non-injury incident (near miss) that involves potential exposure to laser radiation exceeding the MPE. A written summary of an injury or non-injury incident shall be forwarded to the University LSO not later than five working days following the incident. The Laboratory LSS or Authorized User shall maintain records of any incident.

Appendix 1

Beam Control Precautions

1. Do not look directly into the beam or at a specular reflection, regardless of its power.
2. Terminate the beam at the end of its useful path.
3. Locate the beam path at a point other than eye level when standing or sitting at a desk.
4. Orient the laser so that the beam is not directed toward entry points to the controlled area or toward aisles.
5. Minimize the possibility of specular and diffuse reflections.
6. Securely mount the laser on a stable platform.
7. Limit beam traverse during adjustments.
8. Clearly identify beam paths. Ensure the path does not cross into areas, study areas, desk areas, or traffic paths.
9. A beam path that exits from a controlled area must be enclosed wherever the beam irradiance exceeds the MPE.
10. Minimize reflective objects in the laboratory.
11. Be aware that cooling systems or any liquid condensate can provide a specular reflective surface.
12. Utilize appropriate eye protection during beam alignment and beam instrument manipulation.

Appendix 2

Non-beam Control Precautions

This section references ANSI Z136.1 "For the Safe Use of Lasers" Section (7). Non-beam controls refer to hazard controls associated with:

- electricity
- noise
- chemicals
- cryogenics
- other hazards.

Until this appendix is completed in more detail the primary interim reference is The Laser Safety Institute of America Guide to Non-beam Hazards Associated with Laser Use, 1999. A copy of this reference is available from the University LSO and can be ordered through the Laser Safety Office.

Special note: the only fatalities associated with the use of lasers are by electrocution, even though most of the emphasis of the regulations and policy is eye damage.

WARNING!

During periods of installation, maintenance, repair, calibration and any other procedures that result in the accessibility to high-voltage components, the concern for electric shock is paramount!

See Section 8.0 of this Laser Safety Program

Appendix 3

Laser Authorization Application

All class 3b and 4 lasers used at the University of Maryland, Baltimore are required to be operated under an Authorization from Environmental Health and Safety (EHS) [See Section 3.1 Registration Information]. Safe laser use and procedural compliance are the responsibility of the faculty or staff member who is assigned as the Laboratory Laser Safety Supervisor (LSS).

To register your laser, please complete an Application for the Possession and Use of Lasers in Basic Research and send it to:

UMB Laser Safety Officer
Environmental Health and Safety
714 W. Lombard
Baltimore, MD 21201

Appendix 4

Laboratory Laser Survey

Yes-No-N/A

1. Labels and Signs

- Is the correct warning label affixed to the laser? Yes No N/A
- Are signs posted clearly near the laser? Yes No N/A
- Are all accesses to the room properly posted? Yes No N/A
- Is a label, sign, or warning posted near the aperture? Yes No N/A
- Is a label or warning posted near an interlock? Yes No N/A

2. Engineering Controls

- Does each laser have a key switch or entry password? Yes No N/A
- Is appropriate safety eyewear provided and present? Yes No N/A
- Do safety covers have interlocks? Yes No N/A
- Are latches or interlocks provided to restrict access to the controlled area? Yes No N/A
- Are all warning devices functioning within design specifications? Yes No N/A
- Are any items in or near beam paths that could cause specular reflections? Yes No N/A
- Is a physical barrier present at the controlled area entry? Yes No N/A

3. Procedural Controls

- Is each laser registered properly? Yes No N/A
- Is access to the NHZ restricted? Yes No N/A

Does each person have required training?

Yes No N/A

Is the SOP for the laser present at the control?

Yes No N/A

Are curtains up and used (If required)?

Yes No N/A

Is documentation available?

Yes No N/A

Appendix 5

Laser Safety Standard Operating Procedure (SOP) Outline

I. Introduction

- a. Location of laser (site, building, room)
- b. Diagram of room layout
- c. Description of each laser
 1. Classification
 2. Lasing medium
 3. Beam characteristics
 4. Divergence
 5. Aperture diameter
 6. Pulse length
 7. Repetition rate
 8. Maximum output
- d. Application of the beam

II. Hazards

- a. Identify beam and non-beam hazards
- b. Analysis and control

III. Controls

- a. Access Controls (door interlocks, signs, etc.)
- b. Beam Controls (key locks, enclosures, shutters, etc.)
- c. Electrical Controls on High Voltage
- d. Eye protection types
- e. Any medical surveillance requirements
- f. Other controls as needed

IV. Operating Procedures

- a. Initial preparation of laboratory
 1. key position
 2. warning lights on
 3. interlocks activated
 4. identification of all personnel present
- b. Personnel protection requirements acknowledged by persons present
- c. Target area
- d. Countdown procedure
- e. Shutdown procedure
- f. Special procedures
 1. Emergency procedures
 2. Alignment procedures

V. Training

- a. Environmental Health & Safety Training
- b. Specific training for laser use
- c. Maintenance and repair training if applicable

VI. Responsibilities

- a. Supervisor for normal operations
- b. Emergency coordinator
- c. Operators and other personnel

VII. Miscellaneous

- a. Visitor regulations at site
- b. Other as applicable