Laser Safety Program

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SMU EHS

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Introduction

The Southern Methodist University Laser Safety Program Manual sets forth controls and safety guidance for research and educational activities involving lasers. Additional guidance documents are available from the American National Standards Institute (ANSI) Safe Use of Lasers (Z-136.1) and the Texas Administrative Code (TAC 289.301). For the purpose of this document, Laser shall refer to only Class IIIb and Class IV lasers.

1.0 Organization

The Laser Safety Program shall be administered by the University Laser Safety Officer (LSO) within the Office of Risk Management (ORM) Environmental Health and Safety group.

2.0 University Laser Safety Officer (ULSO) *(See also section 4.2)*

The University Laser Safety Officer ORM staff member who has the knowledge and responsibility to apply appropriate laser radiation protection rules, standards, and practices.

3.0 Laser Registration and Permitting

Classification of lasers shall be in accordance with American National Standards Institute specification ANSI Z136.1. All Class IIIb and Class IV lasers shall be registered at SMU and a Permit issued by the University LSO. Lasers which are classified as IIIa or lower, but which contain an IIIb or IV laser, shall be controlled at the higher classification if the class IIIb or IV laser is accessed. Any class IIIb and IV laser will be referred to as "laser" unless otherwise noted. Each Permittee shall be responsible for establishing and supporting laser safety for the Permitted laser.

3.1 Registration Information

Each laser which is possessed, purchased, donated, manufactured, created, assembled or otherwise received by any person or entity at the University shall be registered with SMU.

A Laser Registration Form and Permit Application is provided as Appendix 1 to this document.

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 registrant shall provide disposition information to the University LSO prior to 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.

4.0 Laboratory Personnel

4.1 Permittee

The Permittee is the person whose name appears on the Permit for the laser. Typically, this is the Principal Investigator or Teaching Laboratory Supervisor and, must be permanent faculty or staff (not a postdoctoral fellow or a graduate student). The Permittee is responsible for:

1. Laser Safety in the laboratory
2. Ensuring the availability of correct protective eyewear. (See section 6.5)
3. Providing a Laser Safety Standard Operating Procedure (SOP). (See Section 6.1)
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. Completing laser Permitting with the University LSO
8. Notifying the University LSO immediately if an exposure incident occurs
9. Notifying the University LSO if a laser is decommissioned, sold, or transferred.

The Permittee may designate any of these responsibilities to a Laboratory Laser Safety Officer.

4.2 Laboratory Laser Safety Officer (LLSO)

Each Permittee may designate a Laboratory Laser Safety Officer (LLSO) and identify the Laboratory LSO to the University (ULSO). This person may be the Permittee 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 Permittee retains the function and title of the Laboratory LSO.) The Laboratory LSO 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 LSO, acting under the Permittee's authority, has the responsibility to institute corrective actions including shutdown of laser operations when necessary due to unsafe conditions.

4.3 Laser Operator 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 training records should be documented. An example of appropriate documentation can be found in Appendix 4. The laser operator/user is responsible for:

1. Following laboratory administrative, alignment, safety, and standard operating procedures while operating the laser.
2. Keeping the Laboratory LSO fully informed of any departure from established safety procedures.

5.0 Maximum Permissible Exposure (MPE) and Nominal Hazard Zone (NHZ)

An 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.

When any class IIIb or IV laser is used at levels at or above IIIb 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 other words, ***the NHZ (nominal hazard zone) will 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 IIIb levels.*** This is done to account for intentional or unintentional scattered or reflected beam. If the Laboratory LSO believes the NHZ does not apply to the whole area he may justify a more limited NHZ in the SOP by using information supplied by the laser manufacturer, by measurement, or by using the appropriate laser range equations or other equivalent assessments.

6.0 Required Laser Standard Operating Procedure (SOP) Features

6.1 Laser Safety Standard Operating Procedure

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

6.2 Safety Interlocks and Warning Systems

A safety interlock is a device that automatically prevents human access above 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, as specified in subparagraph §289.301(r)(3)(E) of the referenced regulation, 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 IIIb or IV 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.

6.3 Safety Interlocks-Alternatives

The regulations recognize that in situations where an engineering control (automatic safety interlock) may be inappropriate.

Where safety latches or interlocks are not feasible or are inappropriate a **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 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 Permittee or Laboratory LSO must contact the appropriate agency as necessary and must notify the University LSO 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 controlled area must be established and posted.

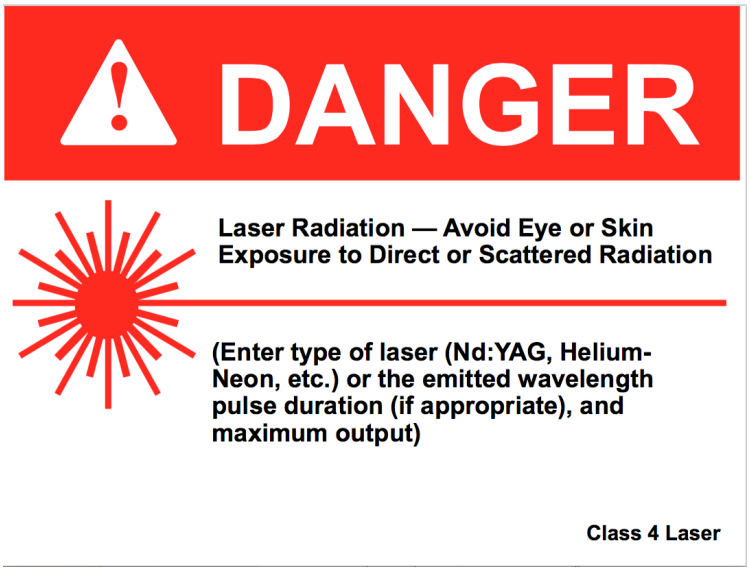
6.4 Signage

The Laboratory Laser Safety Officer is responsible for ensuring that appropriate signage is displayed at all potential entrances to the area where lasers are in use. The signs must be designed in accordance with ANSI Z535. A CAUTION sign should be used for Class 2 and 2M Lasers.

A DANGER sign should be used for Class 3R and **MUST** be used for class 3B and 4 Lasers.

Sign information shall conform to the following specifications:

1. Above the sunburst, precautionary instructions or protective action details are inserted such as:
    a. Laser Protective Eyewear Required
    b. Invisible Laser Radiation
    c. Knock Before Entering
    d. DO NOT ENTER when light is illuminated
    e. Restricted Area
2. Below the sunburst, the type of laser (i.e. Nd:YAG, Helium-Neon, etc.), the emitted wavelength, pulse duration (if applicable), and maximum output SHALL be written
3. The bottom right hand corner SHALL include the class of laser or laser system.



6.5 Training

Every person who operates or works with a laser shall complete training in laser safety provided by the University or University LSO-approved equivalent. This training is referred to as the General Laser Safety Training is offered as an online course through Environmental Health and Safety in The Office of Risk Management. Persons completing General Laser Safety Training shall also complete specific laser safety training given by the Permittee or Laboratory LSO. No person may work in a NHZ prior to completing both laser safety training classes. All training must be documented.

6.6 Protective Eyewear

Each Permittee shall provide protective eyewear that meets the requirements of 25 TAC §289.301(t)(1). 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 a class IIIb or IV beam is 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 Miscellaneous Safety and Training Issues

1. Persons working in a laboratory with lasers but not working directly in the NHZ shall be made aware of the various wavelengths and other operating parameters by the laser operator/users. Training shall include general hazard awareness and precautions to be followed. This training will be given and documented by the Permittee or Laboratory LSO.
2. Persons working with tunable lasers, or any laser which is frequency doubled or frequency tripled, shall be aware of the effect of frequency manipulation and shall choose protective eyewear which will provide protection for the effective wavelength of the laser. This training will be given and documented by the Permittee or Laboratory LSO.

6.8 Surveys

Each Laboratory LSO shall survey the laboratory containing the laser(s) for which the Permittee is responsible. The survey shall be performed using the Laser Survey Form (appendix 3). The survey shall be performed at least annually, 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. Surveys are to be performed by the Permittee or the Laboratory LSO. Survey records shall be retained for inspection by the University LSO. The University LSO or their designee will perform an annual survey as well.

6.9 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 which results in access to radiation in excess of the MPE, shall take place in a 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 LSO must inform the University LSO and include justification for lack of opaque cover in the SOP.

6.10 Skin protection

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.

6.11 Magnification of Laser Beam

If at any time a laser beam is optically magnified or concentrated, special precautions shall be taken by the Permittee 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.

8.0 Non-Radiation Hazards

Each Laboratory LSO 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.

9.0 Incident Reporting

Each Permittee shall immediately seek appropriate medical attention for the injured individual and notify the Office of Risk Management at 214-768-2083 by of any exposure injury involving a laser possessed by the University. For emergencies, call SMUPD at 214-768-3333. The University LSO shall 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 University LSO not later than two working days following the incident. Records of any incident shall be maintained by the Laboratory LSO.

Appendix 1 – Beam Control Precautions

Beam Control Precautions

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

Appendix 2 – Laser Registration Form

SMU

Date Received:_____
Reviewed by:_____ Date:_____
Laser Permit #:_____

Office of Risk Management
Environmental Health and Safety

LASER REGISTRATION FORM

All Class 3B and Class IV lasers are required to be registered with the SMU Office of Risk Management EHS Department. Please complete this form and return via email to bchance@smu.edu.

A. Registration Information

Principal Investigator:		
Office Phone Number:	Email Address:	
Laser Operators:		
Laser Manufacturer:		
Model Number:	Serial Number:	
Department:	Building:	Room:

B. Laser Information

Laser Classification:	☐ Class 3B	☐ Class IV	
Active Medium (i.e. Argon, Nd:Yag, Dye):			
Tunable? ☐ Yes	☐ No		
Wavelengths (nm):			
Beam Divergence (milirads):			
Beam Diameter (millimeters):			
Beam Type:	☐ Continuous Wave	Average Power:	
	☐ Pulsed	Joules per Pulse:	Pulse Repetition Frequency (Hz):
	☐ Q-switched	Pulse Width:	Joules per Pulse:
	☐ Other		
Purpose and Frequency of Use:			
Other Comments:			

C. Protective Eyewear Currently Available

	Pair A	Pair B	Pair C
Eyewear Manufacturer:			
Model:			
Optical Density (i.e. OD>5+ from 730-855nm):			
Visible Light Transmission:			
Number of Pairs in Lab			

Completed by **Signature:**_____ **Date:**

Southern Methodist University PO Box 750231, Dallas TX 75275-0231
214-768-2083, Fax 214-768-4138 www.smu.edu/risk

Appendix 3 – Laser Survey

Laboratory Laser Survey

A. Labels and Signs		**Yes/No/NA**
1	Is the correct warning label affixed to the laser?	
2	Are signs posted clearly near the laser?	
3	Are all accesses to the room properly posted?	
4	Is a label, sign, or warning posted near the aperture?	
5	Is a label or warning posted near an interlock?	
B. Engineering Controls		
1	Does each laser have a key switch or entry password?	
2	Is appropriate safety eyewear provided and present?	
3	Do safety covers have interlocks?	
4	Are latches or interlocks provided to restrict access to the controlled area?	
5	Are all warning devices functioning within design specifications?	
6	Are any items in or near beam paths which could cause specular reflections?	
7	Is a physical barrier present at the controlled area entry?	
C. Procedural Controls		
1	Is each laser registered properly?	
2	Is access to the NHZ restricted?	
3	Does each person have required training?	
4	Is the SOP for the laser present at the control?	
5	Are curtains up and used (If required)?	
6	Is documentation available?	
7	Is appropriate protective eyewear available?	

Appendix 4 – Laser Operator Registration

Laser Operator Registration

Name:
Lab Room number:
Department/Program:

List the permit number or numbers of the Laser the operator will be authorized to operate.

Permit No:	Laser Class:
Permit No:	Laser Class:
Permit No:	Laser Class:

☐GENERAL LASER SAFETY TRAINING
The undersigned completed the SMU General Laser Safety Training Course.
Completion Date:_____

☐SPECIFIC LASER SAFETY TRAINING
The undersigned completed training specific to each laser and laser system listed herein.
Trained By: _____
Completion Date:_____

☐SMU LASER SAFETY WEBSITE/MANUAL
The undersigned has read and is familiar with the contents of the SMU Laser Safety Website/Manual.

☐STANDARD OPERATING PROCEDURES (SOP)
The undersigned as read and is familiar with the operating procedures for the laser(s) listed herein.

☐PERSONAL PROTECTIVE EQUIPMENT
The undersigned has the personal protective equipment described in the SOP available to them, and is familiar with their care and use.

Laser Operator Signature:_____ Date: _____

Permittee or LLSO Signature: _____ Date: _____

Appendix 5 – Laser Incident Report

Laser Incident Report

Send one copy to the Office of Risk Management (riskmanagement@smu.edu). Keep one copy of this form for your files.

Name of Exposed Person:

Supervisor Name: Department: Building:

Lab Room Number: Laser Permit No:

Date the incident took place: Time the incident took place

Description of Laser Incident (Add a typed narrative on attached page if necessary):

Has the incident been reported to the Lab Supervisor? ☐ Yes ☐ No
Has the incident been reported to the Laboratory LSO? ☐ Yes ☐ No
Did this incident involve eye exposure? ☐ Yes ☐ No
Did this incident involve skin exposure? ☐ Yes ☐ No
Was medical treatment sought for the injury? ☐ Yes ☐ No How long after:
Has the incident occurred before in connection with this laser? ☐ Yes ☐ No

Submitted by: Date:

Appendix 6 – Glossary of Terms

Accessible Emission Limit (AEL): Maximum accessible emission level which is permissible in the appropriate class of laser

Accessible Radiation: Laser radiation that can expose human eye or skin in normal usage

Aperture: The opening through which laser radiation can pass

Average Power: Total energy of an exposure divided by the duration of the exposure

Aversion Response: Action, such as closing of the eye or movement of the head, to avoid exposure to laser light

Beam Diameter: Diameter of the laser beam where to power per unit area of the beam is 1/e times that of the peak power per unit area

Continuous Wave (CW) Laser: A laser which with a continuous output that is greater than or equal to 0.25 s

Infrared Radiation: Electromagnetic radiation of wavelength from 700 nm to 1mm

Irradiance: power per unit area, expressed in watts per square centimeter

Laser: Acronym for Light Amplification by Stimulated Emission of Radiation

Laboratory Laser Safety Officer (LLSO): Individual who has the authority to monitor and enforce the control of lasers in a specific lab.

Maximum Permissible Exposure (MPE): The maximum level of laser radiation to which a human can be exposed without adverse biological effects to the eye or skin

Nominal Hazard Zone (NHZ): The zone inside which laser radiation that is direct, reflected, or scattered exceeds the MPE for the laser.

Nominal Ocular Hazard Distance (NOHD): Distance along the axis of the direct laser beam to the human eye beyond which the MPE of the laser is not exceeded

Pulsed Laser: Laser which delivers energy in single or multiple pulses which are less than or equal to 0.25 s in duration.

Radiant Energy: Laser energy emitted, expressed in joules (J)

Radiant exposure: Radiant energy per unit area, expressed in joules per square centimeter

Radiant Power: laser power emitted, expressed in watts (W)

Repetitively Pulsed Laser: Laser with multiple pulses with a pulse repetition frequency greater than or equal to 1 Hz

Specular Reflection: Mirror-like reflection

Ultraviolet Radiation: Electromagnetic radiation with wavelengths from 180-400 nm

University Laser Safety Officer (ULSO): Individual who has the authority to monitor and enforce the control of lasers at SMU.

Visible Radiation: Electromagnetic radiation which is visible to the human eye; wavelengths from 400-700 nm

Appendix 7 – General Beam Control Precautions

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

Appendix 8 – ANSI Safety Control Measures

Laser Safety Control Measures (adopted from ANSI Z136.1)

Laser Hazard Classification

Classes of Lasers (adopted from ANSI Z-136.1)

1. Class 1 lasers and laser systems cannot emit accessible levels of radiation that are capable of causing eye injury under any normal operating condition. (A more hazardous laser may be embedded in a Class 1 product that is not accessible during normal operating conditions, but may be during service and maintenance.
2. Class 2 lasers and laser systems are visible lasers with an accessible output # 1 mW. Class 2 lasers and laser systems are incapable of causing eye injury unless intentionally viewed directly for an extended period.
3. Class 3a lasers and laser systems have an accessible output between 1-5 mW and do not pose a serous eye hazard unless viewed through optical instruments.
4. Class 3b lasers and laser systems have an accessible output 5-500 mW for continuous wave lasers and < 0.125 J within 0.25 second for a pulsed laser. Class 3b lasers and laser systems pose a serious eye hazard from viewing the direct beam or specular reflections.
5. Class 4 lasers and laser systems have an accessible output > 500 mW for a continuous wave laser and > 0.125 J within 0.25 second for a pulsed laser. Class 4 lasers and laser systems pose a serious eye hazard from viewing the direct beam, specular reelections and diffuse reflections. Class 4 lasers and laser systems also pose skin and fire hazards.

Control Measures for all Laser Classes

The purpose of control measures is to prevent exposure to laser radiation above the MPE. Use engineering controls whenever possible. When engineering controls are not able to reduce exposure below the MPE, administrative controls and personal protective equipment should be used.

A. Protective Housing
    a. Place lasers in protective housings whenever practical. When protective housings are not practical, ORM shall perform a hazard analysis to ensure that control measures are implemented to ensure safe operation.
    b. Protective housings or service panels enclosing embedded Class 3b and 4 lasers shall be interlocked or fastened closed requiring special tools for removal.
    c. 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:

i. Restricted access to the area.
ii. Control of the beam to prevent the beam and reflections from extending beyond the area.
iii. 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.
iv. A warning sign posted outside the area.

B. Collecting Optics

Collecting optics used to view the laser beam or its interaction with a material shall have permanently attached attenuators, filters or shutters to prevent hazardous level of radiation from entering the eye.

C. Beam Control
   a. Ensure the beam height is not at the normal eye position of a person in a standing or seated position.
   b. Position the laser so that the beam is not directed toward doorways or aisles.
   c. Securely mount the laser system to maintain the beam in a fixed position during operation and limit beam movements during adjustments.
   d. Ensure beam path is well defined and controlled.
   e. Terminate the beam at the end of its useful path.
   f. Confine beams and reflections to the optical table. The addition of beam-stopping panels to the sides of the optical table is recommended.
   g. If the beam path extends beyond the optical table, a physical barrier shall be used to prevent accidental exposure.
   h. Have only diffusely reflection materials in or near the beam path, where feasible.
   i. Absorb unwanted reflections. Scatter is not permitted.

D. Additional Requirements for Class 3b and 4 Lasers.
   a. Entryway Controls
      i. Doors must be closed and locked during operations
      ii. Doors must be properly posted and warning light energized (if applicable).
      iii. All windows must be covered unless a beam enclosure is used.
   b. Safety controls must not be overridden. These include:
      i. Defeating interlocks
      ii. Removal of shutters
      iii. Rewiring interlock connectors