OLD DOMINION UNIVERSITY

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Occupational Safety & Health • Environmental Health • Laboratory Safety • Industrial Hygiene • Radiation Safety • Hazardous Waste • Pollution Prevention

Laser Safety Manual

Administered by:

Environmental Health & Safety Office

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1. Glossary of Terms

Accessible Emission Limit (AEL): The maximum accessible emission level permitted within a particular laser hazard class.

Accessible Optical Radiation: Radiation to which the human eye or skin may be exposed for the

Engineering Control: A method of controlling employee exposures by incorporating controls into the laser system or design or by modifying the source.

Incidental Personnel: Persons such as housekeepers, maintenance personnel, and emergency personnel who do not frequent areas in which lasers are operated but may have occasional exposure to laser radiation.

Interlock: Typically a switch that, when activated, will interrupt the normal operation of the laser by closing a shutter or de-energizing the system.

Intrabeam Viewing: The viewing condition whereby the eye is exposed to all or part of a direct laser beam or specular reflection.

Laser: A device that produces an intense directional beam of light by stimulating electronic or molecular transitions to lower energy levels. Acronym for Light Amplification by Stimulated Emission of Radiation.

Laser Controlled Area: An area where the activities of those within are subject to control and supervision for the purpose of laser radiation hazard protection, e.g., the laboratory in which a laser is operated.

Laser Personnel: Persons who routinely work around hazardous laser beams. Such persons must be protected by engineering controls, administrative procedures, or both.

Laser Safety Committee: A group consisting of faculty, staff, or administrators that is responsible for overseeing conduct of the Laser Safety Program at Old Dominion University.

Laser Safety Officer: The individual who has the authority and responsibility to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

Laser System Supervisor: Generally, the Principal Investigator (PI) who oversees specific laser facilities, laser equipment, and protective equipment, and ensures that users of a specific laser system have received the appropriate training and approval to operate the laser system.

Maximum Permissible Exposure (MPE): The level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the eye or skin. Factors that determine the MPE for a particular laser include the wavelength of the light, the exposure duration, and the power or radiance of the laser.

Nominal Hazard Zone (NHZ): An area in which the level of direct, reflected or scattered laser radiation exceeds the applicable maximum permissible exposure (MPE). Exposure levels beyond the boundary of the NHZ are below the appropriate MPE. The NHZ may be a smaller area located within a laser controlled area, or it may consist of the entire laser controlled area. The NHZ should be clearly identifiable.

Nominal Ocular Hazard Distance (NOHD): The distance along the axis of the unobstructed beam from a laser, fiber end, or connector to the human eye beyond which the irradiance or radiant exposure is not expected to exceed the applicable MPE.

Non-Beam Hazard: A class of hazards that result from factors other than direct human exposure to the laser beam.

Optical Density (OD): A measure of the amount of attenuation, either absorptive or reflective, provided by a medium.

Specular Reflection: A mirror-like reflection. Specular reflections occur when the size of surface irregularities or roughness is less than the wavelength of the incident light.

Shall: In the context of Old Dominion University's Laser Safety Manual, shall means mandatory.

Should: In the context of Old Dominion University's Laser Safety Manual, should means advisory.

4. The Laser Safety Officer

The Laser Safety Officer (LSO) is granted, by virtue of his/her training and experience, the authority and responsibility for monitoring the use of lasers at Old Dominion University. The LSO is also responsible for the evaluation of laser hazards and, in concert with the Laser Safety Committee, establishment of appropriate control measures. Specific responsibilities of the LSO include:

- Develop and provide laser safety training, as necessary.
- Revise the Laser Safety Manual, as necessary.
- Maintain records of the Laser Safety Program, as required.
- Review and approve applications for User status.
- Investigate and document accidents and non-compliant conditions involving laser use.
- Ensure that corrective actions for unsafe or non-compliant conditions are performed in a timely and appropriate manner.
- In concert with the Laser System Supervisor, evaluate characteristics of a laser system to include:
    - Appropriate laser classification
    - Nominal hazard zones
    - Appropriate control measures
    - Required personal protective equipment, including laser eyewear
    - Required safety equipment, such as barriers and screens.
    - Appropriate signs and labels
- Periodically inspect laser work areas.
- Determine applicability of medical examinations for laser users, and recommend exams as necessary.
- Act as the contact point for regulatory agencies.

The LSO, with the approval of the Laser Safety Committee, reserves the right to terminate any activity involving the use of lasers if it is found to be detrimental to the health of University personnel, the property of Old Dominion University, or the health and/or property of an individual member of the public. Termination of laser activity will proceed as follows:

- The unsafe or non-compliant condition, once identified, is investigated and documented by the Laser Safety Officer. The Laser System Supervisor and Laser Safety Committee are provided with copies of this documentation.
- The Laser System Supervisor is provided the opportunity to respond, in a timely manner, to any findings to the Laser Safety Committee. Any response should include actions that will be taken to correct the unsafe or non-compliant condition.
- If corrective actions are deemed appropriate and satisfactory by the LSO and Laser

Safety Committee, no further action is required.

- If the Laser System Supervisor fails to respond to the LSO or Laser Safety Committee, or fails to take appropriate corrective actions, written warning that termination of laser activity will be considered shall be sent to the Laser System Supervisor and the appropriate department Chair. Copies shall be sent to all members of the Laser Safety Committee. The Laser System Supervisor must respond within two business days following receipt of the warning.
- Failure to correct unsafe or non-compliant conditions shall result in termination of all laser activities. Termination actions shall be reported to the Chair of the appropriate department.

5. Definitions of Laser Users

Users of lasers are classified according to their level of training, experience, and responsibility. There are three types of laser users: Laser System Supervisor, Qualified Operator, and Restricted Operator. User status is required prior to using Class 3B or Class 4 lasers.

5.1. Laser System Supervisor/ Principal Investigator

Laser System Supervisor status is obtained by submitting form LSC-

- Ensuring areas where Class 3B and Class 4 lasers are operated are posted with appropriate signs and warning lights.
- Ensuring that grant proposal budgets include sufficient funding for compliance with this manual. Laser System Supervisors are responsible for purchasing required laser safety equipment

5.2. Qualified Operators

Qualified Operator status is achieved after successfully completed laser safety training (provided by the LSO) and passing a written examination with a score of 75% or better. Persons wishing to apply for Qualified Operator status must submit form-3, LSC "Application for Qualified Operator Status" to the LSO for approval. The LSO will approve the application if the applicant is deemed to have sufficient knowledge and experience to operate a laser independently.

A Qualified Operator will be responsible for the following:

- Maintaining familiarity with the applicable standard operating procedures (SOPs).
- Using appropriate engineering and administrative control measures while operating lasers.
- Wearing appropriate personal protective equipment.
- Notifying the Laser System Supervisor and LSO immediately following a laser accident or unusual occurrence involving the laser.
- Ceasing the operation of the laser immediately in the event of a safety malfunction of the laser system.
- Providing direct supervision over a Restricted Operator if directed to do so by the Laser System Supervisor.

5.3. Restricted Operators

A Restricted Operator is an individual that does not possess adequate training or experience to operator a laser independently. A Restricted Operator may operator a laser ONLY under the direct supervision of the Laser System Supervisor or a Qualified Operator. This user category is intended to allow new hires to start work involving lasers prior to attending laser safety training.

6. Application, Procedures, and General Criteria for Laser Use

7.

8. Medical Surveillance

Any individual with an actual or suspected laser-induced eye injury should be evaluated by a medical professional as soon as possible after the exposure (usually within 48 hours). For laser-induced injury to the retina, medical evaluation shall be performed by an ophthalmologist. Potential skin injuries should be seen by a physician. Referral for medical examination shall be consistent with the symptoms and anticipated effects based on the associated laser system. Records of medical surveillance following a laser incident should be maintained by the Laser Safety Officer (LSO) for at least 30 years.

Any accident involving a laser shall be reported to the LSO. The LSO shall conduct an investigation, which will include interviews with all individuals involved, determination of causes and corrective actions, and documentation of findings.

9. Transfer and Disposal of Lasers

The Laser Safety Officer (LSO) maintains an inventory of Class 3B and Class 4 laser systems. This inventory is verified by the LSO annually. It is essential that the LSO is notified of receipt, transfer, and disposal of lasers.

Transfer or disposal of Class 3B and Class 4 lasers require certain precautionary measures and approval by the LSO. This ensures the safe and responsible disposition of the laser and that the laser inventory is accurate.

The Laser System Supervisor, or responsible party, shall contact the LSO prior to the transfer or disposal of Class 3B and Class 4 laser equipment. The Laser System Supervisor is responsible for ensuring that precautions are taken to mitigate the risk of unauthorized removal or tampering of laser systems.

10. Laser Classification

The laser classification scheme outlined in this section is based on American National Standards Institute (ANSI), Z136.1-2014 “American National Standard for Safe Use of Lasers.” A laser system’s classification is generally designated by the manufacturer. For instances where a laser is not classified or is modified, a detailed hazard analysis shall be performed by the Laser Safety Supervisor or the Laser Safety Officer.

ANSI recognizes four broad classes of lasers, designated as Class 1, 2, 3, and 4. Each class has specific control measures that must be taken when the laser is operating. Laser classification is based on the laser’s ability to cause biological damage to the eyes or skin during use.

10.1. Class 1 Lasers:

Class 1 lasers are the lowest powered lasers normally limited to gallium arsenide lasers and certain other enclosed lasers. These lasers are not considered hazardous even when the output is collected by collecting optics and concentrated into the pupil of the eye. Most lasers do not fall into Class 1 based on output. Rather, they are categorized Class 1 because the laser system has a higher powered laser that has been enclosed with a physical barrier to prevent direct is1 (e)-10 (cM(c)4 (s)2-1 ((h(h a)4 (p)nho-1 ((h-17.9r)-1 (e)-10 ()-6 (r)-1 (ia4 (-4 ()-
Class 8 la5.94 0 T31.66 (e)6 (th)2 (e4 Tw T* [((h)-4 (e l)-2M (he)6 (s)1 (e)0 81 d [(C)-1 (lnt)-2 (o C

Class 3B lasers are capable of causing acute eye damage by either intrabeam viewing or specular reflections. For continuous wave lasers, the output of a Class 3B laser would be greater than Class 3R lasers but less than 500 mW. Class 3B lasers require control measures, training prior to operation, and engineering controls.

10.4. Class 4 Lasers:

Class 4 lasers ("high-risk" or "high-power" lasers) are capable of causing serious eye and skin injury by exposure to the primary beam and by exposure to both specular and diffuse reflections. This class of lasers is also capable of igniting flammable materials and producing laser-generated air contaminants. All Class 4 lasers require control measures, training prior to operation, and engineering controls.

11. Control Measures

Engineering and administrative control measures are required to prevent exposure to laser

- Ensure that only diffusely reflecting material is located in or near the beam path.

11.1.1. *Summary of Engineering Controls*

Engineering controls are the first measures to be employed to ensure laser radiation exposure does not exceed applicable MPEs. Engineering controls are preferred over administrative controls.

11.1.2. ***Summary of Administrative Controls***

Administrative and procedural controls are instructions or work practices that mitigate the potential hazards associated with laser use. Administrative controls are required for the use of Class 3B and Class 4 lasers.

Administrative Control Measure	Classification						
	1	***1M***	***2***	***2M***	***3R***	***3B***	***4***
Standard Operating Procedures	-	-	-	-	-	”	X
Education and Training	-	”	”	”	”	X	X
Authorized Personnel	-	-	-	-	-	X	X
Laser Controlled Area	-	-	-	-	-	X	X
Personal Protective Equipment	-	-	-	-	-	”	X

Legend: X Shall
” 6 K R X O G
- No requirement

11.2. Control Measures for Ancillary Hazards

The Laser System Supervisor shall consider control measures for ancillary hazards based on sound industrial hygiene and safety practices. Specific control measures for ancillary hazards may include, but are not limited to, the following:

11.2.1 Compressed Gases

Specific guidelines for the safe use and storage of compressed gases can be found in Old Dominion University’s Chemical Hygiene -0.0fTd7 (usp) (a)4 (nc)4 (p7i)-2 (t)-2 (y(e Tf -0.004 T
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Administration (OSHA).

- Ventilation systems should be designed and built in accordance with acceptable criteria, i.e. the American Society of Heating and Air Conditioning Engineers (ASHRAE) and the American National Standards Institute (ANSI) specifications.
- Under no circumstances should there be recirculation of LGACs.

Respiratory protection may be provided to control exposures to LGACs or as an interim control measure until engineering and/or administrative controls are implemented. Respiratory protection shall be utilized under the provisions of Old Dominion University's Respiratory Protection Program.

11.2.3. Exposure to Cryogenic Materials

Cryogenic materials, dyes, and other hazardous materials shall be handled in accordance with the instructions provided by the manufacturer or importer, and the applicable provisions of Old Dominion University's Chemical Hygiene Plan:

- Safety Data Sheets (SDS) shall be provided to employees handling hazardous materials.
- Personal protective equipment (PPE), as described on the relevant SDS, shall be provided to each employee. The use of PPE, i.e., lab coats, gloves, and safety goggles, shall be mandatory when handling hazardous and potentially hazardous materials.

11.2.4. Exposure to Toxic and/or Carcinogenic Compounds

Toxic and carcinogenic materials in dyes and/or the solvent used to dissolve them shall be handled in accordance with the instructions provided by the manufacturer or importer, and applicable provisions of Old Dominion University's Chemical Hygiene Plan:

- Safety Data Sheets (SDS) shall be provided to employees handling toxic and/or carcinogenic materials.
- Personal protective equipment (PPE), as described on the relevant SDS, shall be provided to each employee. The use of PPE, i.e., lab coats, gloves, and safety goggles, shall be mandatory when handling toxic and/or carcinogenic materials.

11.2.5. Exposure to Excessive Noise

Hearing protection shall be provided in accordance with OSHA's Occupational Noise Exposure Standard.

11.2.6. Exposure to X-Rays Generated by High Voltage (> 15 kV) Power Supply Tubes

X-ray radiation may be generated by electronic components of the laser system. Laser systems with the potential to generate X-rays (e.g., high voltage vacuum tubes > 15 kV) or other ionizing radiation (e.g., pulsed laser beams with peak irradiance > 10^{18} W/cm^2), shall be evaluated by the Environmental Health and Safety Office as necessary.

11.2.7. Non-Laser Radiation Hazards

In some cases, non-laser radiation resulting from laser use requires additional control measures. Radiation hazards associated with laser non-radiation are wavelength

dependent.

Collateral ultraviolet radiation emitted from laser discharge tubes and pump lamps shall be shielded so that personnel exposures are maintained within the applicable Threshold Limit Value (TLV) specified by the American Conference of Governmental Industrial Hygienists (ACGIH).

11.2.8. Explosion Hazards

Explosion hazards, such as high pressure arc lamps, filament lamps, and capacitor banks, in laser equipment shall be enclosed in housing that is capable of withstanding an explosion. Target and optical elements that may shatter during laser operation shall be enclosed or protected to prevent injury to operators and spectators.

11.2.9. Electrical Hazards

Potential electrical hazards may occur during the course of laser installation, maintenance, and service where protective covers may be removed to allow access to active components. A barrier system should be employed as primary protection against electrical hazards. Other specific control measures to prevent electrical hazards include:

- Metallic frames, enclosures, and other accessible parts of laser equipment shall be grounded by a continuous metallic connection with grounding conductor of the wiring system.
- Enclosures, barriers, and baffles of nonmetallic material shall comply with UL 746C: Polymeric Materials – Use in Electrical Equipment Evaluations.
- The implementation of lockout procedures during maintenance and servicing as specified in Old Dominion University's Lockout/ Tagout Program
- The use of written procedures and protocols for maintenance and service operations.
- Training for operators, maintenance, and service personnel, including current certification in cardiopulmonary resuscitation (CPR).
- The installation of interlock switches and/or "Emergency Power Off" switch to eliminate electrical hazards.
- The installation of bleeder resistors to discharge capacitors.
- The use of a solid metal grounding bar to complete the discharge of capacitor banks when the laser has been serviced less than 24 hours after voltage was applied.
- Additional controls as specified in OSHA regulations and the National Fire Protection Association (NFPA). These requirements include equipment connection to the electrical utilization system, electrical protection parameters, and specific safety training. OSHA requires additional control measures for those circuits operating at more than 50 volts (29CFR, Part 1910, Subpart S).

11.2.10. Fire Hazards

Class 4 lasers can generate beams powerful enough to burn the skin and/or ignite

flammable materials. Additionally, Class 4 lasers are a potential fire hazard if the

12. Signs and Labeling

Signs and warning label dimensions, letter size, font, layout, color, and content shall be in accordance with the American National Standards Specification for Accident Prevention Signs, ANSI Z535.2 “Environmental and Facility Safety Signs”.

All signs and labels shall be conspicuously displayed in locations where laser personnel and ancillary personnel will see them. Area warning signs are required for all Class 3B and Class 4 lasers. Signs and labels may be obtained from the Environmental Health and Safety Office.

Laser area Warning signs shall convey a rapid visual hazard warning message that includes a

13. Eye and Skin Protection

13.1. Eye Protection

Eye protection against radiation should be worn during use of Class 3R, 3B and shall be worn during use of Class 4 lasers within the Nominal Hazard Zone (NHZ) when administrative and engineering controls are impractical to eliminate potential exposures above the Maximum Permissible Exposure (MPE)

Laser eye protection shall be adequate to withstand either direct or diffuse scattered laser radiation under the circumstances of worst case exposure (typically, an ex-1 (ur)3 (e)4 ((()3 (t)-2 (y

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