

University of North Dakota Safety and Environmental Health Office

Standard Practice LSP1	<h2>Laser Safety</h2> <p>Effective Date June 30, 1999</p>
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I. PURPOSE

This Standard Practice establishes policies and procedures for the safe use of class 3b and 4 lasers and laser systems based on ANSI Z136.1-1993: American National Standard for Safe Use of Lasers.

II. POLICY

The University of North Dakota strives to provide a safe and healthy environment for its students, faculty, staff and visitors. This Laser Safety Program is administered through the Radiation Safety and Hazardous Material Committee. This Program includes procedures for the safe use of lasers including labeling and marking of lasers and areas where they are in use, protective measures that must be implemented when using lasers, proper use of protective equipment used during laser operation, and training requirements for all users prior to using lasers.

III. SCOPE

This standard practice applies to all university departments, employees of UND, outside contractors, students, fellows, volunteers, and visiting scholars at the University or University-controlled sites.

IV. REFERENCES

- A. ANSI Standard, Z136.1-1993, American National Standard for Safe Use of Lasers
- B. OSHA Directive, PUB 8-1.7, Guidelines for Laser Safety and Hazard Assessment
- C. American Conference of Governmental Industrial Hygienists, Inc., A Guide for Control of Laser Hazards

V. DEFINITIONS

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- A. Attenuation - Decrease in radiant power caused by an absorbing or scattering medium
 - B. Beam Splitter - An optical device which can produce two beams from a single laser beam by controlled reflection
 - C. Continuous Wave Laser (CW) - A laser which emits for more than 0.25 seconds
 - D. Diffuse Reflection - When an incident laser beam is reflected over a wide range of angles
 - E. Laser - Acronym for Light Amplification by Stimulated Emission of Radiation. A source of intense, coherent, directional beam of optical radiation
 - F. Laser Controlled Area - An area which contains one or more lasers and the activity of personnel is subject to control
 - G. Laser Safety Officer (LSO) - One who has authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.
 - H. Laser System - An assembly of electrical, mechanical and optical components that include a laser
 - I. Laser Supervisor - Individual authorized by the Radiation Safety and Hazardous Materials Committee to possess and use lasers and/or laser systems. Generally the Laser Supervisor is a University Professor and a Principle Investigator. The individual must submit an application to the LSO for review and approval by the Radiation Safety and Hazardous Materials Committee.
 - J. Laser User & Laser Operator - Used interchangeably as a person who uses a laser or laser system. Either the Laser Supervisor or an individual working under the laser supervisor's authorization and supervision.
 - K. Maximum Permissible Exposure (MPE) - the level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. The criteria for MPE for the eye and skin are detailed in Section 8 of ANSI Z136.1-1993.
 - L. Nominal Hazard Zone (NHZ) - the space within which the level of the direct, reflected or scattered radiation during operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the applicable MPE level.
 - M. Nominal Ocular Hazard Zone - The distance, from an operating laser, at which the beam irradiance equals the maximum permissible exposure (MPE) limit
 - N. Pulsed Laser - A laser which emits for less than 0.25 seconds

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- O. Q-Switched Laser - Emits high peak powers for extremely short duration (nanoseconds)
 - P. Repetitively Pulsed Laser - A laser which has a re-occurring pulse repetition rate
 - Q. Specular Reflection - Reflections from shiny surfaces

R. Acronyms:

1. LSO - Laser Safety Officer
2. MPE - Maximum Permissible Exposure
3. NHZ - Nominal Hazard Zone
4. SOP - Standard Operating Procedure

VI. RESPONSIBILITIES

- A. The Radiation Safety and Hazardous Materials Committee is responsible for establishing and administering the laser safety program. The committee will establish and maintain adequate policies for the control of laser hazards.
- B. The Laser Safety Officer (LSO) reports to the Radiation Safety and Hazardous Materials Committee. The Laser Safety Officer shall:
1. Classify, or verify classifications, of lasers and laser systems.
 2. Together with the laser supervisor, be responsible for hazard evaluation of laser work areas, including the establishment of Nominal Hazard Zones (NHZ).
 3. Be responsible for assuring that the prescribed control measures are in effect, recommending substitute or alternate control measures when the primary ones are not feasible or practical, and periodically auditing the functionality of those control measures.
 4. Review standard operating procedures, alignment procedures, and other procedures that may be part of the requirements for administrative control measures for approval by the Radiation Safety and Hazardous Materials Committee.
 5. Review protective equipment i.e., eyewear, clothing, barriers, screens, etc., as may be required to assure personnel safety. The LSO shall assure that protective equipment is audited periodically to ensure proper working order.
 6. Review the wording on area signs and equipment labels.
 7. Review laser installation facilities and laser equipment prior to use (this also applies to modification of existing facilities or equipment).
 8. Review and audit the safety features of the laser installation facilities and laser equipment.
 9. Ensure that adequate safety education and training is provided to laser area personnel.
 10. Determine the personnel categories for medical surveillance.

C. The Laser or Laser System Supervisor is responsible for:

1. The issuance of appropriate instructions and training materials on laser hazards and their control to all personnel who may work with lasers under their supervision.
2. Ensuring that the laser is not operated unless there is adequate control of laser hazards to employees, visitors, and the general public.
3. Submitting names of individuals scheduled to work with lasers to the LSO and, in addition, must submit forms requested by the LSO for medical surveillance scheduling and training completion.
4. Reporting known or suspected accidents. When the supervisor knows of or suspects an accident resulting from a laser operated under his or her authority, the supervisor must immediately notify the LSO or other designated authority.
5. Assisting in obtaining appropriate medical attention for any employee involved in a laser accident.
6. Ensuring that proper approval has been granted before operating new or modified lasers.
7. Ensuring that plans for new laser installations or modifications to existing installations are reviewed and approved prior to implementation.
8. The Standard Operating Procedures and any other procedures necessary for the safe use of the laser. The Standard Operating Procedures must be provided to each user of the laser or laser system.

D. Each affected individual is responsible for:

1. Following the requirements of this Standard Practice, general safety rules, and the Standard Operating Procedure for that laser or laser system.
2. Reporting accidents, or suspected accidents. When an individual operating a laser knows or suspects that an accident has occurred involving that laser, or a laser operated by any other individual, and that such accident has caused an injury or could potentially have caused an injury, he or she must immediately inform the supervisor. If the supervisor is not available, the individual must notify the LSO.

VII. HAZARD EVALUATION AND CLASSIFICATION

A. Laser classification

1. Whenever possible, laser classification will be determined and established by the vendor
2. In instances where laser classification is not supplied by the vendor, for example reconfiguration of a laser system that exposes the beam path of an embedded laser, the LSO shall classify the laser or laser system based on the accessible emission of the laser using Table 1 or 2 of ANSI Z136.1-1993.

B. Hazard evaluation

1. If exposure of unprotected personnel to the primary or specularly reflected beam is possible, determination of the irradiance or radiant exposure at that point is required. Irradiance or radiant exposure will be determined according to Appendix B of ANSI Z136.1-1993.
2. Nominal Hazard Zones (NHZ): In the presence of unenclosed Class 3b and Class 4 beam paths, the LSO shall be responsible for establishing the NHZ. The NHZ will be determined according to section 3.4 and Appendix B of ANSI Z136.1-1993.
 - a. Controls must be in place prior to anyone entering the NHZ. The controls must be adequate to ensure that no one is exposed to greater than the Maximum Permissible Exposure (MPE)
 - b. Since the levels of radiation that escape the NHZ are maintained at or below the MPE, no additional controls are required outside the NHZ.
3. Controlled Area: A laser controlled area must be established whenever there is a NHZ. See item 7 under subsection VIII.A “Engineering Controls”.
4. Operation, Maintenance, and Service: Classification is based on accessible emission during normal operation. Hazards during maintenance and service must be evaluated separately. If necessary NHZs and adequate control measures will be established for maintenance and service procedures.

VIII. CONTROL MEASURES:

The purpose of control measures is to reduce the possibility of human exposure to hazardous laser radiation and to associated hazards such as high voltage. All lasers and laser systems must have control measures sufficient to reduce possible exposures to a level at or below the MPE.

Engineering controls must be given primary consideration in instituting a control measure program with enclosure of the beam path being the preferred method of control. If engineering controls are impractical or inadequate, administrative and procedural controls and/or personnel protective equipment must be used. A check list for Laser System Control Measures is included in Appendix B.

A. Engineering Controls

1. Protective Housings: If practical, class 3b and 4 laser beams should be completely enclosed or embedded in a protective housing. The protective housing should have failsafe interlocks that prevent the laser from operating when any part of the housing is removed or otherwise breached.
 - a. Laser systems containing an embedded class 3b or class 4 laser that are classed by the manufacturer as a class 1 or 2 laser system are exempt from this policy only if the system has not been modified and:
 - i. failsafe interlocks are provided for any portion of the protective housing which, by design, can be removed or displaced during operation, the interlocks must not be defeated, and
 - ii. service access panels which are intended for removal by service personnel only, are either interlocked or require a special tool to remove.
 - b. Classification of lasers or laser systems during maintenance or service will be based on the accessible emissions during those procedures, see item B.4 under Section VII: "Hazard Evaluation and Classification". Maintenance and service procedures on a class 3b or 4 laser embedded in a class 1 laser system are not exempt from the rest of this policy if any interlocks must be overridden, service access panels must be removed or other instances where the beam will be exposed at any time during the procedure.
 - c. Laser systems that have been modified will be reclassified by the LSO prior to use. The reclassification will be based on a thorough review of the accessible emissions due to the modifications, see B.4 under Section VII: "Hazard Evaluation and Classification". A laser system will not be reclassified lower than the manufacturer's original classification.
2. Key control: class 3b lasers or laser systems should be provided with a master switch, class 4 lasers or laser systems must be provided with a master switch that prohibits activation of the laser when in the "off" condition. The master switch must be operated by a key or by an access code.

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3. Viewing portals, display screens, and collecting optics must be designed to maintain laser radiation at the viewing position at or below the MPE for all conditions of operation and maintenance.
 4. Beam Stop or attenuator: Class 3b lasers or laser systems should be provided with a permanently attached beam stop or attenuator, class 4 lasers or laser systems must be provided with a permanently attached beam stop or attenuator. The beam stop or attenuator must be capable of preventing access to laser radiation in excess of the MPE when laser output is not required.
 5. Laser Activation or Warning System: An alarm, a warning light, or a verbal countdown command for single pulse or intermittent operation must be used during activation or startup. Distinctive and clearly identifiable sounds which arise from auxiliary equipment such as a vacuum pump or fan and which are uniquely associated with the emission of laser radiation are also acceptable as audible warning. For class 4 lasers or laser systems the warning system must be activated a sufficient time prior to emission of laser radiation to allow appropriate action to be taken.
 6. Laser Controlled Area: any laser or laser system that has a NHZ must have an established laser controlled area. The laser controlled area must:
 - a. Be posted with the appropriate warning signs at the entryways. Additional postings may be deemed necessary by the LSO. The NHZ must be identified and demarcated as a laser hazard area.
 - b. Be designed to allow rapid egress and to control access by either:
 - i. Non-Defeatable Area or Entryway Safety Controls: the controls must automatically deactivate the laser or reduce the output levels to below the MPE in the event of unexpected entry into the laser controlled area.
 - ii. Defeatable Area or Entryway Safety Controls: For pre-planned situations where personnel must enter or leave the laser controlled area during normal operation. This only applies to situations where an authorized individual must exit or enter the room to achieve a specific objective of the laser's written procedures. The following must apply:
 1. All authorized personnel must be adequately trained and adequate personal protective equipment must be provided upon entry.
 2. Laser radiation at the entryway must be below the MPE. If necessary a blocking barrier , screen, curtain, etc. must be used to attenuate the laser radiation at the entryway to below the MPE.

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3. There must be a visible or audible signal at the entryway indicating that the laser is energized.

iii. Procedural Area or Entryway Safety Controls: For situations where interlocks are not feasible or are inappropriate. Entry is strictly limited to authorized individuals either through the use of a locked door or constant area surveillance. The following must apply:

1. All authorized personnel must be adequately trained and adequate personal protective equipment must be provided upon entry.
2. Laser radiation at the entryway must be below the MPE. If necessary a blocking barrier, screen, curtain, etc. must be used to attenuate the laser radiation at the entryway to below the MPE.
3. There must be a visible or audible signal at the entryway indicating that the laser is energized.

c. Be operated or attended by personnel who have been appropriately trained and authorized.

d. Be operated in a manner that the path is limited when the NHZ of the laser must extend beyond an indoor control area (ie. When the beam travels outdoors), particularly under adverse weather.

e. Have a "Panic Button" or other remote method available for deactivating the laser or reducing the output to levels at or below the MPE. The Panic Button or remote method must be clearly labeled.

f. Have only diffusely reflecting materials in or near the beam path, where feasible.

g. Have the laser secured so that the exposed beam path is above or below eye level of a person in any standing or seated position, where feasible.

h. Have all windows either covered or restricted in such a manner as to reduce the transmitted laser radiation.

i. Require disabling of the laser or laser system, such as removing the key, when not in use to prevent unauthorized use

7. Equipment Labels: All lasers or laser systems must have appropriate warning labels with the laser sunburst logotype symbol and the appropriate cautionary statement. The label must be

affixed to a conspicuous place on the laser housing, control panel, or both if separated by more than 2 meters. All removable protective housing panels must have cautionary labels.

B. Administrative and Procedural Controls: Administrative and procedural controls are methods or instructions which specify rules or work practices to implement or supplement engineering controls.

1. Standard Operating Procedures (SOP's): SOP's are required for all class 3b and class 4 lasers or laser systems. These written SOP's must be maintained with the laser equipment for reference by the operator, and maintenance or service personnel.

2. Output Emission Limitations: levels of accessible power or radiant energy must be limited to that which is commensurate with the required application.

3. Education and Training: Training must be provided for laser supervisors, laser users/operators, and maintenance or service personnel. The level of training must be commensurate with the level of potential hazard. Training will include all of the topics listed in Appendix A.

4. Alignment Procedures: The SOP must address alignment procedures. The use of low power visible laser light is recommended for alignment procedures.

C. Protective Equipment

1. Eye protection devices which are designed for protection against the specific laser's radiation must be used when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the MPE. Eyewear will be selected in accordance with the criteria in section 4.6.2.3 of ANSI Z136.1-1993.

2. Laser protective windows: Windows that are located within a NHZ must be provided with appropriate absorbing filter, scattering filter, blocking barrier, or screen, which reduces any transmitted laser radiation to levels below the MPE.

3. Laser protective barriers and curtains: Laser barriers must be specifically selected to withstand direct and diffusely scattered beams. Barriers must exhibit a damage threshold for beam penetration for a specified exposure time commensurate with the total hazard evaluation. Barriers cannot support combustion or release toxic fumes following laser exposure.

4. Skin protection: Skin covers must be worn if chronic exposures are anticipated at exposure levels at or near the MPE limits for skin.

IX. MEDICAL SURVEILLANCE:

Personnel who work routinely in laser environments will be subject to the baseline eye examination listed in section 6.3.2 of ANSI Z136.1-1993. Required examinations must be performed prior to participation in laser work. Following any suspected laser injury, the examination must be repeated, in addition to whatever other examinations may be desired by the attending physician. Periodic examination is not required.

Appendix A

Laser Safety Training Program Topics

The following topics will be covered in the laser safety training course:

- a. Fundamentals of laser operation (physical principles, construction, etc.)
- b. Bioeffects of laser radiation on the eye and skin
- c. Relations of specular and diffuse reflections
- d. Nonradiation hazards of lasers (electrical, chemical, reaction by-products, etc.)
- e. Ionizing radiation hazards (x-rays from power sources and target interactions when applicable)
- f. Laser and laser system classifications
- g. Control measures
- h. Overall management and employee responsibilities
- i. Medical surveillance practices (if applicable)
- j. It is recommended that CPR be taught to personnel servicing or working on lasers with exposed high voltages and/or the capability of producing potentially lethal electrical currents.

Appendix B

Laser System Control Measures

Control Measures	Classification	
	3b	4
Engineering controls		
Protective Housing	Preferred ^{1,2}	
Interlocks on Protective Housing	Must ²	
Service Panel interlock or special tool	Must ²	
Without Protective Housing or Interlocks Defeated	LSO Determination ¹	
Key Control	Should	Must
Viewing Portals, Collecting Optics, etc.	MPE	
Beam Stop or Attenuator	Should	Must
Activation Warning Systems	Must	
Emission Delay		Must
Laser Controlled Area	NHZ	
Area Posting	NHZ	
Controlled Access	NHZ	
Authorized, Trained Users Only	NHZ	
Limit the NHZ Outdoors	Must	
Panic Button or remote shut off	Must	
Diffusely Reflecting material in beam Path	Where Feasible	
Beam Path not at Eye Level	Where Feasible	
Covered or Restricted Windows	MPE	
Disable Laser When Not in Use	Must	
Equipment Labels	Must	
Administrative and Procedural Controls		
Standard Operating Procedures	Must	
Output Emission Limitations	LSO Determination	
Education and Training	Must	
Alignment procedures	Must	
Protective Equipment		
Eye Protection	MPE	
Protective Windows	NHZ	
Protective Barriers and Curtains	Should	
Skin Protection	MPE	
Medical Surveillance	Must	

Notes:

MPE means that the device or procedure must maintain laser radiation at or below the applicable MPE for all conditions of operation and normal maintenance.

NHZ means that the condition requires the establishment of a NHZ and a laser controlled area. Specific controls must be established for entry into the laser controlled area

¹ Protective housings are preferred, but it is recognized that in research applications, housings may not be practical. If a Protective housing system does not have interlocks on removable pieces then the user cannot take credit for the housing, in other words the laser system will be classified as if there is no housing present.

²Enclosed systems that do not emit **accessible** laser radiation in excess of class 1 limits will be classified as a class 1 system and as long as all interlocks are functioning the laser will not be subject to any other controls. If maintenance or special procedures require defeating the interlocks, the system will be classified according to the accessible laser radiation level.