LASER SAFETY MANUAL

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

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University of North Carolina Laser Safety Manual Used as Basis

1.0 SDSM&T Laser Safety Policy

The SDSM&T policy on laser safety requires that all lasers and laser systems be operated in accordance with the American National Standards Institute (ANSI) Z136.1 2007, “for Safe Use of Lasers;” and other applicable federal and state regulations. To implement the policy properly while giving the greatest possible latitude to the researcher, all laser operations at SDSM&T must be reviewed and approved by the SDSM&T Laser Safety Officer (LSO).

The primary objective of the SDSM&T laser safety program is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) limit reaches the human eye or skin. Additionally, the program is designed to ensure that adequate protection against collateral hazards is provided. These collateral hazards include the risk of electrical shock, fire hazard from a beam or from use of dyes and solvents, and chemical exposures from use of chemicals and vaporization of targets.

2.0 Roles and Responsibility

2.1 Authorized Laser User

The Authorized Laser User (ALU) is an individual directly responsible for the acquisition, use and maintenance of a particular laser/laser system. Authorized Laser Users are responsible for:

- Provide appropriate warning signs for posting.
- Notifying the Laser Safety Officer prior to the acquisition or fabrication of a new laser so that a preliminary safety review and laser inventory update can be made.
- Ensuring that Laser Standard Operating Procedures (LSOPs), appendix A, are written for Class 3B and all Class 4 lasers and that all laser operators complete laser safety training before they are authorized to operate any laser.
- Establishing and maintaining a current list of personnel approved to operate specific types of Class 3B or 4 lasers under their supervision and providing a copy of the list to the LSO.
- Immediately notifying LSO in the event of a suspected overexposure to the output beam from a Class 3B or 4 laser.

2.2 Laser Operators

All personnel operating lasers must follow general laser safety training from EHS and any manufacturer’s laser-specific safety guidelines for the laser they are operating.

2.3 Laser Safety Officer

The Laser Safety Officer (LSO) is responsible for to the following:

- Maintain records of all Class 3B and 4 lasers and laser operators.
- Provide assistance in evaluating and controlling hazards:
  - Provide assistance to ALU on establishing appropriate controlled areas
  - Calculate MPE and NHZ as necessary and appropriate
  - Provide guidance on proper protective eye wear
- Provide laser safety training for new users.
- Participate in accident investigations involving lasers.
- Periodically audit the departmental Laser Safety Program.

3.0 Laser Classification

Lasers are divided into a number of classes depending upon the power or energy of the beam and the wavelength of the emitted radiation. Laser classification is based on the laser's potential for causing immediate injury to the eye or skin and/or potential for causing fires from direct exposure to the beam or from reflections from diffuse reflective surfaces. The manufacturer provides the classification for most lasers. For custom-built and modified lasers, the Laser Safety Officer can assist with classification.

3.1 Class 1 lasers

Class 1 lasers are considered to be incapable of producing damaging radiation levels, and are therefore exempt from most control measures or other forms of surveillance. Example: some laser printers.

3.2 Class 2 lasers

Class 2 lasers emit radiation in the visible portion of the spectrum, and protection is normally afforded by the normal human aversion response (blink reflex) to bright radiant sources. They may be hazardous if viewed directly for extended periods of time. Example: laser pointers.

3.3 Class 3R lasers

Class 3R lasers are those that normally would not produce injury if viewed only momentarily with the unaided eye. They may present a hazard if viewed using collecting optics, e.g., telescopes, microscopes, or binoculars. Example: HeNe lasers above 1 milliwatt but not exceeding 5 milliwatts radiant power; some laser pointers.

3.4 Class 3B Lasers

Class 3B lasers may cause severe eye injuries through direct or specular exposure. Examples: continuous lasers not exceeding 500[mW] for any period greater than 0.25[s]; pulsed visible lasers not emitting more than 30[mJ] per pulse; pulsed IR or UV lasers not emitting more than 125[mJ] during any period less than 0.25[s]."

3.5 Class 4 lasers

Class 4 lasers are a hazard to the eye from the direct beam and specular reflections and sometimes even from diffuse reflections. Class 4 lasers can also start fires and can damage skin. Example: Lasers operating at power levels greater than 500 mW for continuous wave lasers or greater than 0.03 J for a pulsed system.

4.0 General Laser Safety Requirements for Class 3B and 4 Lasers

Requirement	Laser Class	
	3B	4
Warning label	X	X
Registration with Notification to LSO	X	X
Warning Sign	X	X

LSO Notification of Laser Requisition*	X	X
General Laser Safety Training	X	X
Laser-Specific Safety Training	X	X
Laser SOP	- -	X
Controlled Area	X	X
Laser Key Control	- -	X
- - Recommended X Required *Notification applies when a laser setup is remodeled significantly whereby the original hazards assessment or SOP is no longer valid.		

4.1 Class 3B Requirements

1. Do not aim the laser at an individual's eyes.
2. Permit only properly trained & authorized personnel to operate the laser.
3. Enclose as much of the beam path as possible.
4. Place appropriate beam stops at the end(s) of the useful beam path(s).
5. Restrict the access of unauthorized personnel; control spectators.
6. Operate the laser in a controlled area (as defined by the ALU and LSO or in the SOP), unless the beam path is totally enclosed.
7. Employ a warning light or buzzer to indicate laser operation if appropriate, especially for invisible (UV or IR) lasers.
8. Locate the plane of the laser beam & associated optical devices well above or below the eye level of observers whenever possible.
9. Firmly mount the laser to ensure the beam does not stray from the intended path.
10. Use proper eye protection if eye exposure to the direct beam or a specular reflection is possible.
11. Do not view the beam or its specular reflection with collecting optics without sufficient eye protection.
12. Remove all unnecessary reflective surfaces from the area of the beam path.
13. Should develop SOP for laser operation
14. Should incorporate key control of a master switch that can terminate beam operations.

4.2 **Class 4 Requirements**
(includes all Class 3B requirements and the following)

1. Shall develop an SOP for laser operations.
2. Shall incorporate key control of master switch that can terminate beam operations.
3. Entryway safety controls shall be designed to allow both rapid egress by laser personnel at all times and admittance to the controlled area under emergency conditions.
4. Shall provide for and ensure use of proper eye protection for everyone within the controlled area.
5. Use appropriate shielding between personnel and any beam having sufficient irradiance to pose a serious skin or fire hazard.
6. Use remote viewing methods where feasible (e.g. video monitoring) to accomplish any necessary viewing of the beam.
7. Construct non-specular absorbent beam stops of fire resistant material.
8. Use adequate ventilation and vented enclosures when dealing with excimer lasers due to the presence of toxic gases and fumes.

5.0 Warning Signs and Labels

1. Post warning signs in all areas where Class 3b and 4 lasers are used. Include specific information on the sign regarding the laser hazards, and otherwise comply with the ANSI Z136.1-2007 standard for these signs
2. Consult with the LSO on selection of proper laser warning signs
3. Display warning signs conspicuously in locations chosen to most effectively warn personnel of potential safety hazards.
4. Do not remove laser safety signs unless authorized by the LSO or the ALU for the corresponding laser, and then only after the laser is effectively taken out of operation or enclosed so it may be classified as a class 1 laser system.

6.0 Protective Eyewear

1. Use engineering controls (i.e. enclose the entire beam path) whenever possible to eliminate the need for laser protective eyewear.
2. Wear approved laser protective eyewear as appropriate when working in the controlled area of a class 3B or 4 laser or laser system in an open beam configuration.
3. Consult with the LSO on selection of appropriate laser protective eyewear for each laser.
4. Keep laser protective eyewear in good condition, and replace any damaged or defective eyewear.
5. Label laser protective eyewear with the laser type and/or wavelength of light against which the eyewear is designed to protect.

7.0 Laser Safety Training

Operators of class 3B and 4 lasers or laser systems must, prior to working with the laser(s), successfully complete Laser Safety training as offered by the LSO and obtain specific laser training from ALU for the laser(s).

8.0 Special Requirements for Invisible Laser Beams

Since infrared (IR) and ultraviolet (UV) wavelengths are normally invisible to human eyes, they possess a higher hazard potential than visible light lasers. Therefore, the use of laser eyewear that will protect against the exposure is required at all times during laser operations.

8.1 Infrared Lasers

1. The collimated beam from a Class 3B laser should be terminated by a highly absorbent backstop wherever practicable. Many surfaces which appear dull visually can act as reflectors of IR.
2. A class 4 laser beam should be terminated in a fire resistant material whenever practicable. Periodic inspection of the absorbent material is required since many materials degrade with use.

8.2 Ultraviolet Lasers

1. Exposure to UV should be minimized by using shield material that attenuates the radiation to levels below the appropriate MPE for the specific wavelength.

2. UV radiation causes photochemical reaction in the eyes and the skin, as well as in materials that are found in laboratories. The latter may cause hazardous by-products such as ozone and skin sensitizing agents. The use of long-sleeved coats, gloves, and face protectors is recommended.

9.0 Laser Acquisitions, Inventory and Disposal of Class 3B and 4 Lasers

1. Purchasing Office notifies EHS when orders are placed.
2. LSO will maintain a central inventory of lasers on campus.
3. ALUs are required to report acquisition or fabrication of such devices to EHS by completing schedule E of Laboratory Safety plan.
4. Annual inventories of all lasers will be conducted by LSO.
5. Contact LSO before transferring or disposing of any lasers.

10.0 Laser Accidents and Incidents

1. Report any injuries to employees immediately to SDSM&T Human Resources. If an incident occurs after-hours, call Campus Safety, 6100. For any and all serious injuries call 911 or 9-911 from a campus phone.
2. Report any suspected exposures to the LSO and the ALU for the involved laser(s).
3. Report any accidents or other safety-related incidents (e.g. near misses, etc.) to the LSO and ALU of the involved laser(s). A near miss is an unanticipated event that did not result in harm or injury but definitely had the potential to do so. An example is if a Class 4 laser beam was unexpectedly reflected across the front of the face of a visitor walking into the controlled area. A data base of accidents and near misses will be maintained by the LSO to be used as educational tools and lessons learned for the purpose of increasing awareness to potentially hazardous situations.

11.0 Template for Written Laser Safety Operating Procedures

The template illustrated in appendix A is to be followed when preparing written laser safety operating procedures (LSOP). A written procedure is to include all lasers in a laser system, including alignment lasers. This LSOP must be reviewed and approved by the LSO.

Appendix A - Sample Laser Standard Operating Procedure

Laser:	Date:
Department/Division:	Location:

1. LASER SAFETY CONTACTS
Laser Safety officer _____ Phone:_____
Maintenance/Repair _____ Phone:_____
Medical Emergencies _____ Phone:_____

1. LASER DESCRIPTION
   - Location of laser or laser system (site, building, room).
   - Diagram of area layout (attachment).
   - Description of each laser, including classification, lasing medium, and beam characteristics (divergence, aperture diameter, pulse length, repetition rate, and maximum output, as applicable.)
   - Purpose/application of beam(s).

2. LASER SAFETY PROGRAM
Clearly outline each category below:
   - Responsibilities of the laser operator(s)
   - Laser Training Requirements
   - Laser Registration Requirements
   - Personnel Protective Equipment Requirements
   - Disposal Requirements

3. OPERATING PROCEDURES
   - Initial preparation of laboratory environment for normal operation (key position, outside status indicator on, interlock activated, warning sign posted, personnel protective equipment available, other):
   - Target area preparation:
   - Special Procedures (alignment, safety tests, maintenance tests, other):
   - Operating procedures (power settings, Q-switch mode, pulse rate, other) are as follow:
   - Shutdown procedures are as follows:

4. CONTROL MEASURES

LASER/LASER SYSTEM CONTROLS		
Check if applicable	CONTROL	COMMENTS
[ ]	Entryway (door) Interlocks or controls	
[ ]	Laser Enclosure interlocks	
[ ]	Laser Housing Interlocks	
[ ]	Emergency Stop/Panic button	
[ ]	Master Switch (operated by key or code)	
[ ]	Laser secured to base	
[ ]	Beam Stops/Beam Attenuators	
[ ]	Protective Barriers	
[ ]	Warning Signs	
[ ]	Reference to	

	Equipment manual	
[ ]	Extra Eyewear Available	
[ ]		

COMMENTS:

HAZARDS AND CONTROLS		
Check if applicable	HAZARD	CONTROLS
[ ]	Unenclosed beam/ Access to direct or scattered radiation	
[ ]	Laser at eye level of person sitting or standing	
[ ]	Ultraviolet Radiation/ Blue Light Exposure	
[ ]	Reflective Material in Beam Path	
[ ]	Hazardous Materials/Waste(dyes, solvents, other)	
[ ]	Fumes/Vapors	
[ ]	Electrical	
[ ]	Capacitors	
[ ]	Compressed Gasses	
[ ]	Fire	
[ ]	Housekeeping	
[ ]	Trip Hazard	

COMMENTS:

5. PERSONNEL PROTECTION EQUIPMENT

A. Eyewear

LASER EYEWEAR					
For this laser….			…Wear this eyewear		
Acquisition#	Type	Wavelength(s) (nm)	Wavelength(s) Attenuated (nm)	Optical Density(OD)	Remarks
Example	Nd:YAG	1064,532	1064,532	5+	UVEX

B. Other Protective Equipment Required within Nominal Hazard Zone

ITEM LOCATION USAGE CONDITION

_____ _____ _____

_____ _____ _____

6. OPERATOR REVIEW

I have read and understood this procedure and its contents, and agree to follow this procedure each time I use the laser or laser system.

Name (print) Signature Date

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

Appendix B – Associated Hazards

1. Electrical Hazards	Accidental electrocution while working with high voltage sections of laser systems can be lethal. Electrical hazards are not normally present during laser operation, but great care should always be exercised during installation, maintenance, or servicing. Laser users must ensure that high voltage electrodes are not exposed and that capacitors are correctly discharged. Some laser systems incorporate the use of a water cooling system. The combination of water and electrical hazards of course increase the risk of serious injury.
2. Chemical Hazards	Many dyes used as lasing media are toxic, carcinogenic, corrosive or pose a fire hazard. A material safety sheet (MSDS) should accompany any chemical handled in the laser laboratory. The MSDS will supply appropriate information pertaining to the toxicity, personal protective equipment and storage of chemicals.
3. Collateral Radiation Hazards	Radiation other than that associated with the primary laser beam is called collateral radiation. Examples are x-rays, UV, plasma, radio frequency emissions, and ionizing radiation. X-rays could be produced from two main sources in the laser laboratories: electric-discharge lasers and high-voltage vacuum tubes of laser power supplies, such as rectifiers and thyratrons. A power supply, which requires more than 15 kilovolts (kV), may produce enough x-rays to be a health hazard.
4. UV and Visible Radiation Hazards	Laser discharge tubes and pump lamps may generate ultraviolet and visible radiation. The levels produced may exceed safe limits and, thus cause skin and eye damage.
5. Fire Hazards	Class 4 lasers represent a fire hazard. Depending on the construction material, beam enclosures, barriers, stops and wiring are potentially flammable if exposed to high beam irradiance for more than a few seconds.
6. Explosion Hazards	High-pressure arc lamps, filament lamps, and capacitors may explode violently if they fail during operation. These components are to be enclosed in a housing, which will withstand the maximum explosive force that may be produced. Laser targets and some optical components also may shatter if heat cannot be dissipated quickly enough. Consequently, care must be used to provide adequate mechanical shielding when exposing brittle materials to high intensity lasers.