University of Nebraska Lincoln

Safe Operating Procedure

(Revised 1/14)

LASER CLASSIFICATION AND GENERAL SAFETY CONTROL MEASURES FOR LASERS USED IN RESEARCH

(For assistance, please contact EHS at (402) 472-4925, or visit our web site at http://ehs.unl.edu/)

Scope

This SOP is limited to Class 3B and 4 lasers housed indoors and used in research and development applications. This SOP does not apply to lasers used outdoors or in other applications such as medical use, cutting, teaching activities, etc. Users of this SOP are encouraged to complete the EHS web-based ***General Laser Safety Awareness*** training; the content of this SOP is a summary of the information provided in the training.

Regulatory Authority

The content of this SOP is based on the following primary authoritative sources:

- ANSI Z136.1, Safe Use of Lasers
- ANSI Z136.8, Safe Use of Lasers in Research, Development, or Testing
- NFPA 115, Standard for Laser Fire Protection

Laser Classification

Lasers are classified as 1, 1M, 2, 2M, 3R, 3B, and 4 based on the potential for producing injury to the eye or skin during intended use. A Class 1 laser poses the least risk, while a Class 4 laser poses considerable risk. It is important to understand that the classification is based on accessible levels of non-ionizing radiation during "intended use." Therefore, even a class 1 laser can pose significant hazard if any of the protective features preventing beam access are compromised or defeated, such as when servicing. Most lasers used in R&D are Class 3B or 4. See Appendix 1 for a description of each laser classification.

Roles and Responsibilities

At UNL, there is no institutional laser safety program. Rather, individual Principal Investigators (PIs) or other persons who oversee Class 3B and 4 laser operations (Laser Supervisors) are responsible to administer their own laser safety program. Roles and responsibilities of PIs/Laser Supervisors and Operators are summarized below:

- ***PIs/Laser Supervisors*** are responsible to fulfill the duties and responsibilities ordinarily assigned to a Laser Safety Officer (LSO) under the referenced standards, or delegate such responsibility to an appropriately qualified individual and provide adequate oversight of such delegation. Specific duties and responsibilities of the LSO include:
  - Evaluate all hazards (beam and non-beam) of lasers under their authority.
  - Ensure laser use facilities are appropriately designed and configured to ensure safety.
  - Establish policies and procedures that minimize the hazards (beam and non-beam) of lasers under their authority.
  - Determine those persons who are authorized to conduct various laser operations (e.g., set-up, alignment, operation, maintenance, service) and train operators accordingly.

- Review and approve intended uses of lasers by persons under their supervision/guidance.
- Prescribe and provide appropriate personal protective equipment (PPE). Periodically inspect PPE to verify its integrity. Replace PPE as appropriate and necessary.
- Establish and enforce restrictions and procedures for entry to laser use areas.
- Monitor adherence to policies, procedures, and facility design/configuration requirements by laser users and take immediate action to abate uncontrolled hazards.
- Ensure that actions in response to a laser injury conform to standard UNL occupational injury procedures as described in the EHS SOP, ***On-the-Job and Student Injuries***.
- Determine whether a medical surveillance program is appropriate and implement if applicable.

- ***Operators*** are responsible to:
  - Refrain from energizing or working with or near a laser unless authorized to do so by the LSO and being appropriately trained in laser-specific and task-specific hazards and control measures.
  - Refrain from modifying a laser or prescribed use conditions unless authorized to do so by the LSO.
  - Adhere to all established policies and procedures.
  - Consistently use PPE and report PPE deficiencies immediately to the LSO.
  - Promptly report all injuries or other incidents that could have resulted in property damage or injury involving a laser to the LSO and EHS (for "near-miss incidents" see the EHS Near Miss Reporter on the EHS web page under the "home" tab).

Administrative Control Measures

Following are minimum administrative control measures that must be observed for Class 3B or 4 lasers.

- ***Training*****:** All persons working with Class 3B and 4 lasers must receive adequate training commensurate with assigned tasks/duties. EHS provides web-based General Laser Safety Awareness training. EHS General Laser Safety Awareness training must be supplemented with laser-specific training administered by the LSO to include:
  - Beam and non-beam hazards and hazard mitigation strategies.
  - Boundaries of the Laser Control Area (LCA) and Nominal Hazard Zone(s) (NHZ), and access restrictions.
  - Description of tasks that the operator is authorized to perform and the procedures that shall be followed when performing those tasks.
  - Instruction regarding changes to the laser operating conditions must be authorized by the LSO.
  - Instruction regarding specific PPE to be worn and when, as well as, how to inspect and obtain replacement PPE.
  - Instruction on the location and operation of emergency controls.

  Laser operators are likely to require training on other topics such as Chemical Safety, General Electrical Safety, etc. See the EHS ***Training Needs Assessment*** at http://ehs.unl.edu/Training_Needs_Assessment.pdf.

- ***General Precautions for Beam Hazards***: General beam hazard administrative control strategies include but are not limited to the following:
    - Use the minimum power possible for the intended application.
    - When conducting alignment, use lower power visible lasers for path simulation of higher power lasers. If infeasible, use beam display devices to locate beams and use lowest power setting possible. During alignment processes:
        - Post appropriate warning signs if the alignment conditions could result in exposures in excess of the Maximum Permissible Exposure (MPE) in the LCA.
        - Use beam blocks and/or laser protective barriers when alignment beams could stray into areas with uninvolved personnel.
        - Locate and block all stray reflections before proceeding to the next optical component or section.
        - Be sure all beams and reflections properly terminate before high-power operation.
        - Replace any enclosures or beam blocks removed as part of the alignment process before resuming normal operation.
    - Do not look directly into a beam even when wearing eye protection.
    - Allow only essential and authorized persons in the LCA while the laser is in operation.
    - Barriers, curtains, and other materials that may be in the beam path must be non-combustible and exhibit a damage threshold for beam penetration for an appropriate exposure time commensurate with the total hazard evaluation. Not all materials have the same damage threshold.
    - Do not override or circumvent engineering controls (e.g., barriers, enclosures, etc.) during routine operation.
    - Consistently wear prescribed and appropriate PPE and replace as necessary.

- ***General Precautions for Non-Beam Hazards***: General non-beam hazard administrative control strategies include but are not limited to the following:
    - Install electrical equipment/components in accordance with applicable Electrical Codes. Typically installation should be coordinated through UNL Facilities Management.
    - Do not locate high voltage supplies and capacitors close to water sources, e.g., cooling water pumps, lines, emergency showers, etc.
    - Run power cords in a manner that they are not a trip hazard, subject to abrasion or damage, and away from water sources.
    - Do not use extension cords to power lasers/laser components.
    - Enclose toxic, corrosive, pyrophoric, and reactive gases in a ventilated cabinet, as applicable. See EHS SOP, ***Gases Under Pressure Hazards and Risk Minimization***.
    - When there is potential for Laser Generated Airborne Contaminants (LGACs), use properly designed and installed local ventilation (e.g., snorkel drops, portable fume extractors, etc.) to capture contaminants at the source.
    - Be diligent to ensure that combustible materials are located well away from potential beam paths.

Laser Control Area (LCA) Design Features and Laser Configuration

If the Nominal Hazard Zone (NHZ) has not been clearly defined with barriers or calculated Maximum Permissible Exposures (MPEs), then the NHZ is assumed to encompass the entire LCA.

- Post appropriate warning signs at each entrance to the LCA ("Danger," class & type of laser, pulse duration, maximum output, OD for prescribed eyewear, etc.).
- Access must be controlled to ensure that only authorized persons are able to enter the LCA.
    - For Class 3B LCAs, locks are sufficient but should be augmented with appropriate warning signs. Laser status indicator lights are not mandatory, but are encouraged.
    - For Class 4 LCAs, there are three options. All options require a laser status indicator light. Emergency shut-down controls are required when there is risk of fire due to the power of the laser and its configuration/features/uses. When feasible, the most restrictive option is desirable. In all options, the laser controls must be located a safe distance from the laser system, preferably outside of any area where the MPE may be exceeded.
        - Option 1: Utilizes non-defeatable safety latches, entryway or area interlocks (e.g., electrical switches, pressure sensitive floor mats, infrared detectors, etc.) to deactivate the laser or reduce the output to a level at or below the applicable MPE in the event of entry into the LCA.
        - Option 2: This option can be used if features of option 1 are infeasible due to the intended use of the laser (e.g., long term testing and warm up periods make it infeasible for cycling of the laser in response to entry/exit). In this case, the design is similar to option 1 but incorporates a means for overriding the entry controls by authorized persons.
        - Option 3: This option is appropriate when safety latches or interlocks are impractical or inappropriate (e.g., enclosed or limited open beam paths, fiber operations, etc.). While safety latches or interlocks are not used, there must still be restricted access (e.g., electronic or manual lock). A door, wall, screen, curtain, or other means must be used to attenuate the laser radiation to less than the MPE at the entryway.
- Orient the laser such that its beam is directed away from the entrance door and is above or below eye level of a person in a standing or seated position.
- Only diffusely reflecting materials should be located in or near the beam path. Consider any place where a reflector can be placed to cause an intentional or inadvertent reflection of the beam, e.g., dropped paper clip, etc. Items to the side and above the beam path should be secured to prevent tipping over or falling into the beam path.

Personal Protective Equipment (PPE)

PPE must be used when enclosure of the beam or other control measures do not prevent access to direct or reflected beams at levels above the MPE. The EHS General Laser Safety Awareness Training course provides more detail on PPE selection. PPE will generally consist of laser safety eyewear and clothing that covers exposed skin (e.g., lab coats, long-sleeved shirt, gloves, etc.).

- Proper eyewear selection requires consideration of the wavelength, maximum output energy/power of the laser, and maximum beam radiant exposure/beam irradiance. Consult the manufacturer regarding your specific application. Inspect eyewear before each use and discard if damaged.
- Skin injuries from lasers primarily fall into two categories- thermal injuries (burns) from acute exposure to high power laser beams and photochemical injury from exposure to UV radiation emitted from lasers operating in this wavelength range. When exposure to UV radiation may exceed the skin MPE, tightly woven garments that cover the arms and

hands are appropriate. UV- protective face shields are also recommended in these conditions. Flame retardant materials should be selected for class 4 lasers.

Medical Evaluation
Medical surveillance and evaluations of laser workers may be necessary for chronic laser exposure or for accidental exposures. The primary concern is an accidental exposure to the eyes. Any suspected over-exposure (e.g., exposure exceeding MPE) from laser radiation to the eyes should immediately prompt an eye examination by a qualified physician. Subsequent re-examinations and follow-ups may be necessary.

Waste Considerations
Many chemicals and laser components may be regulated when disposed. In general, do not discard any chemical or laser component as ordinary refuse unless specifically authorized by EHS. Tag all unwanted/spent materials for collection by EHS. See EHS SOP, ***Hazardous/Radioactive Material Collection Procedures***.

Export Control
There are federal export control laws and regulations that prohibit the unlicensed export of certain commodities or information for reasons of national security or protections of trade. This includes oral, written, electronic, or visual disclosure, shipment, transfer, or transmission of commodities, technology, information, technical data, assistance or software codes. Lasers sometimes can fall into the Export Control Regulations. PIs/Laser Supervisors should consult with UNL's Export Control Office.

Appendix 1: Laser Classifications

Class 1 Lasers are considered incapable of producing damaging radiation levels during normal operation and do not require any special protective control measures. However, special protective measures may be necessary if any of the protective features preventing beam access are compromised or defeated, such as when servicing.

Class 1M Lasers are considered incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with an optical instrument. Class 1M lasers do not require any special protective control measures other than observance of a prohibition on unprotected optically aided viewing. Special protective measures may be necessary if any of the protective features preventing beam access are compromised or defeated, such as when servicing.

Class 2 and 2M Lasers emit visible light (0.4 to 0.7 um) and have an average radiant power of <1mW. Eye protection is normally afforded by the aversion response. Class 2M lasers are potentially hazardous if viewed with optical aids. Class 2M lasers do not require any special protective control measures other than observance of a prohibition on unprotected optically aided viewing. Special protective measures may be necessary if any of the protective features preventing beam access are compromised or defeated, such as when servicing

Class 3 Lasers may be hazardous under direct and specular (mirror) reflection viewing conditions, but are not normally a diffuse (reflected in many directions) reflection or fire hazard.

- Class 3R lasers are potentially hazardous under some direct and specular reflection viewing conditions if the eye is appropriately focused and stable, but the probability of an actual injury is small. The upper limit of the power output of a 3R laser is 5 mW.
- Class 3B lasers may be hazardous under direct and specular reflection viewing conditions but are not normally a diffuse reflection hazard. Eye damage can occur in less than 0.25 seconds. The upper limit of the power output of a Class 3B laser is 500 mW.

Class 4 Lasers are high power (>500 mW). Class 4 lasers pose significant risk for eye and skin injuries. Eye damage can occur in the nanosecond range, which is much quicker than the blink of an eye. Both direct viewing and diffuse reflection are dangerous. Class 4 lasers may also pose additional hazards such as laser generated air contaminants, plasma radiation, and fire.