



CLASS 3B AND CLASS 4 RESEARCH LASERS

This Safe Operating Procedure (SOP) summarizes regulatory and UNL policy requirements to possess and operate Class 3B and Class 4 lasers and laser systems used for research purposes.

NOTE: There may be other types of Class 3B and Class 4 lasers and laser systems that are not directly addressed by this SOP, such as those used for novel research devices and techniques. At a minimum, the purchase, installation, and application of ANY Class 3B or 4 lasers and laser systems must be approved by the Laser Safety Officer and Laser Safety Committee.

Authorization for Possession or Operation

Operation of Class 3B and Class 4 lasers and laser systems must be performed under the supervision of an individual that has been approved by the UNL Laser Safety Committee (LSC). The approved Authorized User (AU) must be a faculty or staff member knowledgeable in the operation of Class 3B and Class 4 lasers and laser systems.

To become an AU:

1. Complete the online Laser Safety training provided by UNL Environmental Health & Safety (EHS).
2. Complete vendor-provided equipment training, if applicable.
3. Complete a Laser Safety Committee project within NuRamp. Each project contains an application for laser use and information regarding each associated laser/laser system.
4. Each laser or laser system must have alignment, operation, and maintenance procedures.
5. Each laser and laser system will have a hazard assessment completed by the EHS Laser Safety Officer.
6. Obtain approval from the Laser Safety Committee.

Registration

All Class 3B and Class 4 lasers and laser systems must be registered with the Laser Safety Officer upon receipt. The AU shall promptly notify the Laser Safety Officer of any such changes in location, operational configuration, or disposal. Maintenance of lasers and laser systems may require a temporary authorization and hazard assessment prior to the beginning of work depending on the nature and scope of the work being done.

Training Requirements

AUs must complete applicable EHS laser safety training initially and complete an annual refresher. Laser Operators (LO) are individuals that are approved to use Class 3B and Class 4 lasers and laser systems under the supervision of the AU.

Laser Operators operating a Class 3B and Class 4 lasers and laser systems must complete the following:

- Online Laser Safety training provided by UNL Environmental Health & Safety (EHS).
- Receive on-the-job training for each laser and laser system used.
- Read and demonstrate understanding of alignment, operation, and maintenance procedures for each laser and laser system.
- Annual laser safety refresher training.

Hazard Assessments by the Laser Safety Officer

The Laser Safety Officer (LSO) will conduct a hazard assessment for each device registered to an AU in active use. The assessment remains valid when a device is stored if the operating conditions do not change when work resumes. Stored or inactive devices with no intent of use or that are otherwise inoperable do not require a hazard assessment.

A reassessment may be required under certain circumstances. If any of the circumstances listed occur, it is the responsibility of the AU to promptly notify the LSO to schedule a hazard assessment if needed:

- Following any changes to operational configurations, control measures, and/or operational parameters; OR
- Following any maintenance requiring disassembly, removal, or addition of a local component in the laser device or laser system that may affect the operational characteristics; OR
- Any time a visual inspection of local components in the system or its control measures reveals an abnormal condition; OR
- After any incident or accident from a failure of control measures or procedures.

The hazard assessment evaluates the intended operational configuration for each laser device or system as specified in the device registration. The assessment details the acceptable operating conditions for a laser or laser system that must be adhered to by the AU and LOs.

The classification and operational configuration of a laser or laser system are used to determine the potential hazards and the appropriate control measures necessary for safe operation. These include but are not limited to:

- Identifying potential beam hazards due to an open or enclosed beam configuration.
- Determining the Nominal Hazard Zone (NHZ), Nominal Ocular Hazard Distance (NOHD), Accessible Emission Limit (AEL) and defining of the Laser Control Area (LCA).
- Defining and evaluating control measures such as Personal Protection Equipment (PPE), beam barriers, and safety devices (e.g., interlocks, safety latches, emergency

stops).

- Determining the Optical Density (OD) required for any protective eyewear, viewing windows and any transparent barriers of the LCA.
- Non-Beam Hazards associated with laser device operation such as electrical and fire hazards, Laser Generated Air Contaminants (LGACs), collateral radiation, and physical and chemical hazards associated with the device operation.

Control Measures

Control measures are the means to mitigate potential hazards associated with the use of lasers. Control measures can be divided into three groups:

- **Engineering Controls:** control measures designed or incorporated into the laser or laser system, for example, interlocks, shutters, and watch-dog time, or its application, for example, protective barriers, area warning device, Class 4 entryway controls, and emergency stop.
- **Administrative (Procedural) Controls:** control measures incorporating administrative means, for example, training, posted signage, and operating procedures to mitigate potential hazards associated with laser use.
- **Personal Protective Equipment (PPE):** means personal safety protective devices used to mitigate hazards associated with laser use, for example, laser protective eyewear, protective clothing, and gloves.

A controls hierarchy will be followed when implementing controls to mitigate laser hazards. Engineering controls should be the first line of defense, followed by administrative controls, and the last line of defense is PPE. Enclosure of the laser equipment or beam path is the preferred method of control because the enclosure will isolate or minimize the hazard. If engineering controls alone are inadequate, an effective combination of engineering, administrative, and PPE controls must be used to provide adequate protection. PPE must be used when mitigation cannot adequately be ensured using engineering and administrative control measures.

Laser Specific Safe Operating Procedures

Safe Operating Procedures (SOPs) are step-by-step written instructions of the procedures to be followed in performing alignments, routine operations, and maintenance procedures for each laser and laser system. An SOP is required for each laser or laser system that describes the type of work being done by a Laser Operator (LO) and is reviewed and approved by the Authorized User (AU) and the Laser Safety Officer (LSO). The SOP must be kept with the laser and laser systems and available to all laser operators.

These procedures must include:

- Specifications of the laser and laser systems
- Purpose of the laser and laser systems
- Laser Operators and Unauthorized Personnel
- Description of hazards that may be encountered with the laser research project

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- Description of the employed hazard control measures
- Personal protective equipment (PPE) requirements
- Operating Procedures that include alignment, routine operations, and maintenance
- Emergency Procedures

Any deviation from the approved safe operating procedures requires approval from the AU and the LSO.

Determination of Laser Classification

Laser manufacturers are responsible for providing accurate and comprehensive laser safety information for their products. Manufacturers classify lasers and laser systems based on their design specifications, output characteristics, and intended use, adhering to laser safety standards and regulations.

If the classification of a laser or laser systems cannot be determined by the manufacturer specifications, the classification will be made by the Laser Safety Officer (LSO) by evaluating the laser's wavelength, output power, and other relevant parameters to determine the appropriate controls.

Until the laser classification is determined, implementing safety measures appropriate for a higher laser classification level may be necessary. This may include more control measures and using personal protective equipment (PPE) suitable for higher hazard levels.

A Class 3B or Class 4 laser and laser system can be modified by the Authorized User and reclassified by the LSO if it meets the Accessible Exposure Limit (AEL) for the different classification. Modification or alteration of a laser or laser system may necessitate recertification, reclassification, and/or compliance reporting and should not be undertaken without consulting the LSO. If a laser or laser system is reclassified to a lower level, it strictly applies to emitted laser radiation hazards and not to other potential non-beam hazards.

Embedded Laser Systems

Embedded lasers are found in lasers and laser systems with lower classification ratings, typically Class 1. However, these products may have Class 3B or Class 4 laser in their protective and interlocked housings. When the Class 1 laser system is used as intended with functional interlocked systems, no additional control measures are required. When an embedded laser system is opened and the higher classification laser radiation is accessible, such as during maintenance or alignment, the requirements for safe operation of the higher class shall be followed.

Transfer

Transfer of lasers and laser systems is permissible within UNL if the device recipient has been approved by the UNL Laser Safety Committee (LSC) as an Authorized User (AU). The following actions are required:

- Notify the Laser Safety Officer (LSO) of the intended change in ownership/custody and
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location of the laser or laser system. A new hazard assessment will be conducted prior to operation of the laser or laser system.

- The new AU must complete a new LSC project NuRamp as described in the Authorization for Possession or Operation section above.
- Relocation of a laser or laser system may require additional precautions if the device contains hazardous materials that could be released during transport. It is the responsibility of the users to take the necessary precautions for the safe relocation of the equipment.

Contact the Laser Safety Officer and UNL Export Controls if a laser or laser system is to be transferred to another person, both inside and outside of the institution to ensure compliance with regulatory requirements, including but not limited to laser manufacturer standards and export control considerations.

Disposal

Lasers and laser systems are likely to contain components or materials subject to waste disposal regulations and may not be disposed of as ordinary refuse. Disposal of lasers or laser systems should adhere to the following guidelines:

- Notify the Laser Safety Officer regarding the intent of disposal of the laser or laser system. This will initiate discussion regarding the disposal process and next steps.
- If a device remains operable or serviceable, the laser or laser system may be transferred to another AU as outlined in the Transfer section above. This should not be done as storage in lieu of disposal or if there is no express intent of use by the recipient.
- It may be possible to trade-in or return a laser or laser system to a laser supplier or manufacturer. Some suppliers or manufacturers will accept old devices for recycling or as a service to users.
- Disposal of laser and laser systems may require the removal of hazardous materials or contaminated components, such materials should be disposed of through EHS. This must be done prior to the laser or laser system being picked up for disposal.
- Lasers or laser systems which are to be disposed of will be rendered inoperable and disposed of as permissible.

Reporting of Suspected Beam Exposures

In the case of suspected or actual injury from laser beam or non-beam hazards, operations must cease, and the laser set-up will remain unchanged to allow for analysis of the cause of the accident. Ensure that the laser system is shut off.

Notify any staff in the area, the Authorized User, and the Laser Safety Officer at 402.472.4925 to initiate an exposure investigation. For after-hours assistance, call the University Police Department at 402.472.2222 for situations that pose an immediate threat to human health or property.

If an individual requires medical attention for a life-threatening injury or in the case of fire, contact emergency responders at 911 first, then the Laser Safety Officer.

Medical surveillance and evaluations of laser workers may be necessary for accidental exposures. Any suspected exposure exceeding MPE from laser radiation should be promptly evaluated by a qualified physician at a medical care facility listed on the EHS SOP, **On-The-Job and Student Injuries**. Subsequent reexaminations and follow-ups may be necessary.

Definitions

Definitions to assist in the implementation of this SOP are provided below and are from ANSI Z136.1, *Safe Use of Lasers*, and other applicable standards.

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

Beam means a collection of light and photonic rays characterized by the direction, diameter (or dimensions) and divergence (or convergence).

Collateral Radiation means any electromagnetic radiation, except laser radiation, emitted by a laser system. This does not include laser target interaction radiation (reradiation).

Control Measures means actions or methods used to mitigate potential hazards associated with lasers. Control measures can be divided into three groups: engineering, procedural (administrative), and personal protective equipment (PPE).

Embedded Laser means an enclosed laser that has a higher classification than the laser system in which it is incorporated, where the lower classification of the system is appropriate because of the engineering feature limiting accessible emission.

Enclosed Beam means a laser or laser system where the beam path cannot be entered by any part of the body and exposure from a beam reflection is not possible during normal operation.

Interlock means a device or engineered system that prohibits access to an area where direct exposure to laser beam radiation is possible.

Laser Classification means an indication of the beam hazard level of a laser or laser system during normal operation. The hazard level of laser or laser system is represented by a number or a numbered capital letter. The laser classifications are Class 1, 1M, 2, 2M, 3R, 3B and 4.

Laser Controlled Area (LCA) means a laser use area where the occupancy and activity of those within is controlled and supervised. That area may be defined by walls, barriers, or other means. Potentially hazardous beam exposure is possible within the LCA.

Laser Eye Protection means laser eye protection that limits the amount of incoming laser radiation that the wavelength, number of wavelengths, or band of wavelengths. Can be configured as spectacles, goggles, visors, window, viewing screens, to mean anything that can be laser eye protection.



Laser means a device that produces radiant energy predominantly by stimulated emission. Laser radiation may be highly coherent temporally, spatially, or both. An acronym for Light Amplification by Stimulated Emission of Radiation.

Laser System means an assembly of electrical, mechanical, optical components that includes a laser.

Maintenance means activities performed to keep a laser system functioning optimally. This includes regular upkeep tasks such as cleaning, calibration, repairs, troubleshooting, and inspection of laser components.

Maximum Permissible Exposure (MPE) means the level of laser radiation to which an unprotected person may be exposed without adverse biological changes in the eye or skin.

Nominal Hazard Zone (NHZ) means the space within which the level of the direct, reflected, or scattered radiation may exceed the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the applicable MPE.

Nominal Ocular Hazard Distance (NOHD) means 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 does not exceed the applicable MPE.

Non-beam Hazards (NBH) means all hazards arising from the presence of a laser system, excluding direct human exposure to direct or scattered laser radiation.

Open Beam means a laser or laser system beam where an individual could place some part of their body into the laser beam path or exposure is possible from a beam reflection during normal operation.

Operation means the performance of laser or laser system over the full range of its intended functions e.g. normal operation.

Optical Density (OD) means the logarithm of the base ten of the reciprocal of the transmittance of light at a particular wavelength through a material.

Personal Protective Equipment (PPE) means personal safety protective devices used to mitigate hazards associated with laser use and includes laser protective eyewear, protective clothing, gloves, etc.

Safety Device means a device, interlock, or system that prevents the entry of any portion of an individual's body into the primary laser beam path or that causes the beam to be shut off upon entry into its path.