University of New Mexico

Laser Safety Program

Prepared by UNM Department of Environmental Health & Safety

Reviewed and Approved by UNM Chemical & Laboratory Safety Committee

Maintained by UNM Environmental Health & Safety Department

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TABLE OF CONTENTS

REVISION LOG

Rev. No.	Date Approved	Description	Pages Replaced
0	12/13/20217	Initial release of the UNM Laser Safety Program	N/A
1	9/23/2021	Updated all pages	All
2		Updated Acronyms and Definitions Updated References Updated PI and LSO Responsibilities, Section 6 Added CLSC Responsibilities, Section 6 Updated Section 10, Limited Open Beam Path Removed Class 3R from Registration Requirements, Section 11 Updated Incident Report Link, Section 12 Updated Section 14 with Homebuilt and Disabled Laser Information Updated Section 15 with Multiple Laser and Unattended Operation Signage Updated Section 15 with labeling for small lasers Added precautions to Optical Fiber section (18) Added alignment precautions to Section 20 Updated Export section (23)	None
3	4/2024	Added Commitment to Safety and Accident/Incident Procedures	None
4	4/2025	Updated tables to reflect updated ANSI standards, Added Eyewear Considerations, Added Disposal Considerations, Added PPE to Optical Fiber section	None

LIST OF ACRONYMS

AEL	Accessible emission limit
ANSI	American National Standard for Safe Use of Lasers
CDRH	Center for Devices and Radiological Health
CFR	Code of Federal Regulations
CW	Continuous Wave
DSLO	Deputy Laser Safety Officer
EHS	Environmental Health and Safety
EOHS	Employee Occupational Health Services
FAA	Federal Aviation Administration
IEC	International Electrotechnical Commission
IR	Infrared radiation
LCA	Laser controlled area
LEP	Laser Eye Protection
LGAC	Laser Generated Air Contaminants
LSO	Laser safety officer
MPE	Maximum permissible exposure
ND:YAG	Neodymium doped yttrium-aluminum-garnet
NHZ	Nominal Hazard Zone
nm	Nanometer
NOHD	Nominal ocular hazard distance
OD	Optical density
OSHA	Occupational Safety and Health Administration

PI	Principal Investigator
PPE	Personal Protective Equipment
SHAC	Student Health and Counseling
SOP	Standard operating procedure
UV	Ultraviolet radiation

Definitions

Accessible emission limit (AEL) – The maximum accessible emission level permitted within a particular laser hazard class.

Collateral radiation – Any electromagnetic radiation, except laser radiation, emitted by a laser system.

Collimated beam – Effectively, a “parallel” beam of light with very low divergence or convergence.

Continuous wave (CW) – A laser operating with a continuous output for a period ≥ 0.25 seconds.

Diffuse reflection – Change of the spatial distribution or "scattering" of a beam of radiation when it is reflected in many directions by a surface or by a medium.

Electromagnetic radiation – The flow of energy consisting of orthogonally vibrating electric and magnetic fields lying transverse to the direction of propagation. Gamma rays, X-rays, ultraviolet, visible, infrared, and radio waves occupy various portions of the electromagnetic spectrum and differ only in frequency, wavelength, and photon energy.

Embedded laser – An enclosed laser that has a higher classification than the laser system in which it is incorporated, where the system’s lower classification is appropriate due to the engineering features limiting accessible emission.

Enclosed laser – A laser that is contained within a protective housing of itself or of the laser or laser system in which it is incorporated. Opening or removal of the protective housing provides additional access to laser radiation above the applicable MPE than possible with the protective housing in place.

Infrared radiation (IR) – Electromagnetic radiation with wavelengths which lie within the range 700 nm to 1000 µm.

Interlock – An engineering control designed to prevent access to laser radiation above the applicable MPE when activated.

Laser – a device that produces radiant energy predominately by stimulated emission. Laser radiation may be highly coherent temporally, spatially, or both. The spectrum of electromagnetic radiation ranges from the ultraviolet region through the visible to the infrared region. An acronym for Light Amplification by Stimulated Emission of Radiation.

Laser classification – An indication of the beam hazard level of a laser or laser system during normal operation, or the determination thereof. The hazard level of a laser or laser system is represented by a number or a numbered capital letter.

Laser controlled area (LCA) – Any area, permanent or temporary, that contains hazardous laser operations. Hazards associated with the laser operation must be evaluated and mitigated by the use of appropriate control measures at the boundaries of and within the LCA.

Laser safety officer (LSO) – One 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 – An assembly of electrical, mechanical, and optical components which includes a laser.

Maximum permissible exposure (MPE) – 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) – 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 appropriate MPE level.

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 hazards (NBH) – A class of hazards that result from factors other than direct human exposure to a laser beam.

Optical Density (OD) – The logarithm to the base ten of the reciprocal of the transmittance at a particular wavelength.

Optically aided viewing – Viewing with a telescopic (binocular) or magnifying optic. Under certain circumstances, viewing with an optical aid can increase the hazard from a laser beam.

Protective housing - An enclosure that surrounds the laser or laser system and prevents access to laser radiation above the applicable MPE. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing limits access to other

associated radiant energy emissions and to electrical hazards associated with components and terminals, and may enclose associated optics and a workstation.

Pulsed laser – A laser that delivers its energy in the form of a single pulse or a train of pulses. The duration of a pulse is less than 0.25 seconds.

Retinal hazard region – Optical radiation with wavelengths between 400nm and 1400nm, where the principal hazard is usually to the retina.

Shall – Required

Should - Recommended

Standard operating procedure (SOP) – Formal written description of the safety and administrative procedures to be followed in performing a specific task.

Ultraviolet radiation (UV) – Electromagnetic radiation with wavelengths which lie within the range 180 nm to 400 nm.

Viewing window – A visually transparent part of an enclosure that contains a laser process. It may be possible to observe the laser processes through the viewing windows.

Visible radiation – Electromagnetic radiation with wavelengths which lie within the range 400 nm to 700 nm and can be detected with the human eye.

1. UNM's Commitment to Safety

Safety is a core value of the University of New Mexico. UNM is committed to creating and fostering a culture of safety within the community. Part of that commitment includes providing resources and references for the safe operation of LASERs. To learn more about UNM's commitment to safety, visit https://ehs.unm.edu/culture-of-safety.html.

2. Policy

The University of New Mexico is committed to:

- Providing a safe and healthy work and educational environment that is free from recognized hazards that could be responsible for injury or illness;
- Protecting the University's assets; and
- Ensuring the University's impact on the environment is positive.

To achieve these goals the University has an extensive loss control program administered by the University Environmental Health and Safety Department. This program is described in "Risk Management" Policy 6100, UBP. The University Environmental Health & Safety Department works with the Loss Prevention Control Committee to identify, evaluate, and control hazards and potential losses.

The ultimate responsibility for safety, however, cannot be delegated as a staff function, it must be assumed by every member of the University community. Faculty, staff, and students must comply with all University safety, health, and environmental programs, rules, regulations, and policies designed to prevent accidents and job-related illnesses, and to protect the environment. A safe environment reduces the risk of accidents and associated costs, improves employee morale, and increases productivity.

3. Purpose

This program is designed to assure the safety of University of New Mexico (UNM) faculty, staff, students and visitors from potential health hazards associated with the use of lasers. To achieve this goal, the University has adopted the American National Standard for Safe Use of Lasers in Research, Development, or Testing, ANSI Z136.8-2021, and American National Standard for Safe Use of Lasers, ANSI Z136.1-2022.

These documents are national consensus standards that are recognized laser safety standards. As allowed in Z136.1, guidance contained in Z136.8 can be used for Research and Development

specific applications that may not have been fully addressed or are in conflict with Z136.1. It is up to the discretion of the UNM Laser Safety Officer to determine which standard(s) apply to a particular laser activity.

4. Program Description

This program addresses the following Laser Safety Program provisions required in ANSI Z136.1-2022.

- Designation of a Laser Safety Officer with the authority and responsibility to evaluate and control laser hazards, implement appropriate control measures, as well as monitor and enforce compliance with required standards and regulations
- Education of authorized personnel in the safe use of lasers and laser systems and as applicable, the assessment and control of laser hazards
- Application of adequate protective measures
- Incident investigation and preparation of action plans for the prevention of future accidents

5. Scope

This program applies to all non-clinical lasers owned or operated in facilities under the control of University of New Mexico.

6. Regulatory and National Consensus References

OSHA 29 CFR 1910.132, Personal Protective Equipment
OSHA 29 CFR 1910.133, Eye and Face Protection
American National Standard for Safe Use of Lasers (ANSI Z136.1-2022)
American National Standard for Safe Use of Lasers Outdoors (ANSI Z136.6-2005)
American National Standard for Safe Use of Lasers in Research, Development, or Testing (ANSI Z136.8-2021)
Federal Laser Product Performance Standard (21 CFR Parts 1040.10 and 1040.11)
CDRH *Laser Notice 53, https://www.fda.gov/radiation-emitting-products/laser-products-and-instruments/frequently-asked-questions-regarding-laser-notice-53-guidance-industry-and-fda-staff-approval*

7. RESPONSIBILITIES

7.1. Deans, Directors, and Department Heads

- Ensure departmental compliance with the UNM Laser Safety Program
- Assign a Deputy Laser Safety Officer (DLSO) for his/her work area(s)
- Provide the DLSO with the training and support necessary to implement and maintain the Laser Safety Program
- Ensure that safety audit findings are resolved in a timely manner

7.2. Principal Investigator (PI) or Deputy Laser Safety Officer (DLSO)

- Ensure that laser users comply with the UNM Laser Safety Program and do not operate laser systems without proper training and authorization
- Provide site-specific training on the operation and safe use of Lasers and maintain training records
- Develop Standard Operating Procedures and submit them to the LSO for review
- Review procedures for potential safety problems before assigning to other personnel
- Ensure that required engineering controls are maintained and functioning properly
- Ensure that the proper administrative controls are in place
- Ensure that personal protective equipment is available, maintained properly, and used
- Ensure that required signage and equipment labels are in place and legible
- Conduct regular, formal laser safety and housekeeping inspections, including routine inspections of emergency equipment
- Report incidents of actual or suspected exposure to harmful laser radiation to the University LSO/Environmental Health & Safety and, if necessary, assist in obtaining the appropriate medical attention for those involved
- Report the acquisition of new Lasers to EHS and ensure that Lasers are properly registered, using the Laser Registration Form on EHS's website: Laser Safety :: Environmental Health & Safety | The University of New Mexico (unm.edu)
- Report the relocation, transfer, decommissioning or disposal of laser(s) to the University LSO/Environmental Health & Safety

7.3. Laser Users

- Plan and conduct laser operations in accordance with the UNM Laser Safety Program, applicable laboratory-specific SOPs, and any other further safety recommendations made by the PI, DLSO, or University LSO
- Consult with the PI, DLSO, or University LSO whenever there are any questions regarding laser use
- Use all required engineering controls and personal protective equipment

- Only operate lasers and associated equipment for which they have been formally trained
- Only operate lasers and associated equipment for which they have been authorized to by the PI/supervisor
- Report any questions on health and safety, or any unsafe or unhealthy working conditions to the PI, DLSO, or University LSO
- Report incidents of actual or suspected exposure to harmful laser radiation to the PI and LSO

7.4. Environmental Health and Safety

- Develop and maintain a University-wide laser safety program
- Maintain a current University-wide inventory of Class 3B and Class 4 laser systems
- Develop and provide Laser Safety training and training materials
- Provide printed laser area signs and equipment labels to laser users
- Assist departments and laboratories with site-specific training
- Assist departments and laboratories in developing SOPs
- Ensure that periodic audits of Class 3B and Class 4 laser systems are conducted and documented
- Oversee the investigation of incidents of actual or suspected exposure to harmful laser radiation
- Maintain current copies of applicable standards and regulations that are available to University departments and individual laser personnel
- Assign a Laser Safety Officer
- Assist departments with disposal of hazardous dyes and chemicals associated with laser use

7.5. Laser Safety Officer

- Establish and maintain the policies and procedures for the laser safety program
- Classify or verify hazard classification of lasers and laser systems
- Conduct hazard evaluation of laser work areas
- Specify and assure that control measures are implemented and maintained
- Review and approve Class 3B and Class 4 standard operating procedures (SOPs)
- Recommend or approve personal protective equipment (PPE)
- Review and approve area signs and equipment labels
- Review and approve Class 3B and Class 4 laser installations, facilities and laser equipment prior to use, including modification of existing facilities or equipment
- Assure adequate training of laser personnel
- Maintain required records such as training records, audits, laser inventories, and SOP approvals

- Perform periodic audits or surveys of each Class 3B and Class 4 laser or laser system
- Investigate and document incidents of actual or suspected exposure to harmful laser radiation
- Approve Class 3B and Class 4 laser system operations
- Obtain and maintain the appropriate training and certifications for Laser Safety Officer
- Report repeated and/or severe violations and/or noncompliance to the Chemical Lab Safety Committee

7.6. Chemical Lab Safety Committee

- Review and approve the Laser Safety Program prior to implementation
- Review reports of repeated and/or severe violations and/or noncompliance
- Determine whether labs with repeated and/or severe violations and/or noncompliance may continue to operate lasers

8. Personnel Training and Qualification

Only qualified personnel are permitted to operate laser systems. The Principal Investigator, Deputy Laser Safety Officer (DLSO), or Laser Safety Officer (LSO) will identify and qualify personnel.

All persons operating laser systems are required to complete an initial laser safety training either via Learning Central, EHS, and/or a department-specific training. A laser safety refresher training must be completed annually thereafter. The initial training must be completed before initial assignment to operate a laser system. In addition, all personnel using Class 3B or Class 4 laser systems must:

- Review the UNM Laser Safety Program
- Review the operating and safety instructions provided by the manufacturer
- Complete laboratory-specific training from the Principal Investigator, or a designee, covering safe operation of the laser(s) to be used, applicable SOPs and alignment procedures

All visitors and spectators of laser system operations are required to complete lab-specific laser safety training.

9. Laser Classification

Lasers and laser systems are classified according to their ability to produce eye or skin injury to personnel. Commercially available lasers manufactured after August 1, 1976 are required to be classified and labeled by the manufacturer. Information on the label must include the laser

class, maximum output power, pulse duration (if pulsed), and the laser medium or emitted wavelengths. When an existing commercial laser is modified, a custom laser is constructed or an unclassified laser is found in the laboratory, it is the responsibility of the Principal Investigator to ensure that the laser system is classified and labeled in accordance with the most recent version of ANSI Z136.1. The classification and labeling must then be verified by the LSO.

The laser hazard classification is based on the hazard level of the accessible laser beam during normal operation of the laser and is represented by a number or a numbered capital letter. The current laser classifications in ANSI Z136.1 – 2022 are Class 1, Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4. In general, the potential beam hazard increases in the same order with Class 1 being the least hazardous and Class 4 being the most hazardous.

- Class 1 – Considered to be incapable of producing damaging radiation levels during operation, and exempt from any control measures or other forms of surveillance.
- Class 1M – Considered to be incapable of producing hazardous exposure conditions unless viewed with collecting optics such as an eye-loupe or a telescope. Exempt from any control measures other than to prevent potentially hazardous optically aided viewing, and is exempt from other forms of surveillance.
- Class 2 – Visible lasers (400 nm to 700 nm) considered incapable of emitting laser radiation at levels that are known to cause skin or eye injury within the time period of the human eye aversion response (0.25 seconds).
- Class 2M – Class 2 lasers that are potentially hazardous if viewed with collecting optics.
- Class 3R – A laser system that is potentially hazardous under some direct and specular reflection viewing condition if the eye is appropriately focused and stable. Class 3R lasers will not pose either a fire hazard or diffuse-reflection hazard. R – Reduced requirements.
- Class 3B – A laser system that may be hazardous under direct and specular reflection viewing conditions, but is normally not a diffuse reflection or fire hazard.
- Class 4 – A laser system that is a hazard to eye and skin from the direct beam, specular reflection, and may pose a diffuse reflection and fire hazard. Class 4 laser systems may also produce laser generated air contaminants (LGAC) and hazardous plasma radiation.

10. ENCLOSED LASERS

If the entire beam path of a laser or laser system is enclosed and the enclosure fulfills all requirements of a protective housing (limits exposure to laser radiation to levels at or below the applicable MPE), the requirements of Class 1 are fulfilled and no further controls are required.

During service, when protective housing is removed, a temporary Laser Controlled Area may be necessary. Please contact the LSO for guidance.

10.1. Protective Housing Requirements

- A label that indicates the relative hazard of laser radiation contained within the housing shall be placed on the housing;
- An interlock system designed to prevent access to laser radiation above the applicable MPE shall be provided;
- Fail-safe or redundant interlocks shall be provided for any portion of the protective housing that, by design, can be removed or displaced during operation and maintenance, thereby allowing access to Class 3B or Class 4 radiation. The use of a tool to remove the housing or covering is acceptable as an alternative requirement to interlocks.
- Testing of the interlocks shall be performed at least annually. Testing shall be performed after the last use of a laser if it is to be idle for a prolonged period of time and prior to re-initialization of a laser if it has been idle for a prolonged period of time. A testing check sheet/log shall be retained by the lab.

11. LIMITED OPEN BEAM PATH

If a hazard analysis defines an extremely limited NHZ and procedural controls provide adequate protection, Class 1 conditions shall be considered as fulfilled if:

- For those limited open beam path lasers or laser systems where analysis confirms that the accessible levels during operation are at or below the applicable MPEs, and
- Where limited open beam paths are such that human access or the placement of a tool as part of normal operation is restricted

12. LASER REGISTRATION

All Class 3B and Class 4 lasers and laser systems and Class 1 laser systems with embedded Class 3B or Class 4 lasers must be registered with Environmental Health and Safety prior to operation. Registration information must be updated when lasers are modified or disposed of. The Laser Registration Form can be found on EHS's website: Laser Safety :: Environmental Health & Safety | The University of New Mexico (unm.edu).

13. LASER ACCIDENTS

Persons with an actual or suspected laser-induced injury should be evaluated by a qualified medical professional immediately after the exposure. University employees should contact

Employee Occupational Health Services (EOHS) at 505- 272-8034. Students should contact Student Health Services at 505-277-7810. If the exposure occurs after hours, employees and students should seek treatment at a hospital emergency room. The supervisor of the injured person and Environmental Health and Safety must be notified as soon as possible after the exposure. A UNM Incident Report Form must be completed and submitted to EHS as soon as possible at Accident, Incident, Near Miss, and Hazard Reporting :: Environmental Health & Safety | The University of New Mexico.

14. Laser Hazard Evaluation

Prior to the operation of new laser systems, or significantly modified systems where the hazard level may have changed, a hazard evaluation must be completed to identify all hazards associated with the laser or laser system and to determine the necessary control measures. The Laser Hazard Assessment Form is included as part of the Standard Operating Procedure Template and can be accessed here in Attachment 1. Both beam and non-beam hazards must be evaluated. In addition to normal operation, maintenance and service activities must also be evaluated.

Factors to be considered in the hazard evaluation are:

* The laser or laser system's capability of injuring personnel or interfering with task performance
* The environment in which the laser is used
* The personnel who may use or be exposed to laser radiation

The PI with the assistance of the DLSO or LSO shall conduct this evaluation.

15. Engineering and Administrative Control Requirements

The purpose of control measures is to reduce the possibility of human exposure to hazardous laser radiation and to nonbeam hazards. Engineering and administrative controls in accordance with ANSI Z136.1-2022 standards are required for commercial lasers and lasers systems used at UNM. Tables 1 and 2 show the ANSI Z136.1-2022 engineering and administrative control requirements and recommendations. At the discretion of the LSO and the UNM committee overseeing lasers, variances to these controls may be allowed when specified controls are not feasible or are inappropriate. However, any controls that deviate from those listed in any of the ANSI Z136 standards must provide an equivalent level of laser safety protection. Any such variances must be documented.

For homebuilt and non-certified lasers, the engineering controls listed are "preferred" but not required per ANSI Z136.8-2012. However, prior to sending a laser or laser system for technology transfer or use by others offsite, an effort should be made to bring them into existing product safety code compliance.

During periods of prolonged non-use, the master switch should be left in a disabled condition (key removed and safely stored, power source removed, etc.).

Table 1. ANSI Z136.1-2022 Engineering Control Measures

Engineering Control	Class 1/1M	Class 2/2M	Class 3R	Class 3B	Class 4
Protective Housing	Required	Required	Required	Required	Required
Without Protective Housing	LSO shall establish Alternative Controls				
Interlocks on Removable Protective Housings*	Required if enclosed 3B/4	Required if enclosed 3B/4	Required if enclosed 3B/4	Required	Required
Service Access Panel	Required if enclosed 3B/4	Required if enclosed 3B/4	Required if enclosed 3B/4	Required	Required
Key Control				Recommended	Recommended
Facility Window Protection				Required	Required
Fully Open Beam Path				Required Nominal Hazard Zone Analysis Required	Required Nominal Hazard Zone Analysis Required
Limited Open Beam Path				Required Nominal Hazard Zone Analysis Required	Required Nominal Hazard Zone Analysis Required
Enclosed Beam Path	None is required if protective housing and/or interlocks on removable protective housings are present.				
Area Warning Device				Recommended	Required
Laser Radiation Emission Warning				Recommended	Required
Class 4 Laser Controlled Area					Required
Entryway Controls					Required
Protective Barriers and Curtains				Required	Required

* Per ANSI Z136.8-2021, housing that requires a tool to open may be substituted in lieu of an interlock.

Table 2. ANSI Z136.1-2022 Administrative Control Measures

Administrative Control	Class 1/1M	Class 2/2M	Class 3R	Class 3B	Class 4
Standard Operating Procedures				Recommended*	Required
Output Emission Limitations				LSO Determination	
Education and Training	Recommended for 1M	Recommended	Recommended	Required	Required
Authorized Personnel				Required	Required
Indoor Laser Controlled Area	May apply with use of optical aids	May apply with use of optical aids		Required Nominal Hazard Zone Analysis Required	Required Nominal Hazard Zone Analysis Required
Class 4 Laser Controlled Area					Required
Temporary Laser Controlled Area	Recommended if MPE exceeded	Recommended if MPE exceeded	Recommended if MPE Exceeded		
Controlled Operations					Recommended
Laser in Navigable Airspace	Recommended	Recommended	Recommended	Recommended	Recommended
Alignment Procedures				Required	Required
Spectators	Recommended for 1M	Recommended for 2M		Recommended	Required
Service Personnel	LSO Determination				

* Required in ANSI Z136.8-2021

16. WARNING SIGNS AND LABELS

All laboratories where a Class 2, Class 2M, Class 3R, Class 3B or Class 4 laser is present shall have a laser warning sign posted at the entrances to the laboratory. Entrances to Class 3B or Class 4 laser laboratories shall have a lighted warning sign (no higher than 6 feet from the floor) that is activated when the laser is energized. The outside boundary of a temporary laser-controlled area shall be posted with a Notice sign.

The following information shall be included on warning signs:

1. The hazard class of the laser-controlled area

2. The contact information for the LSO
3. The OD and wavelength of the LEP to be worn
4. Wavelength and type of laser

The following information may be included on warning signs:

1. "Knock Before Entering"
2. "Invisible Laser Radiation"
3. "Do Not Enter When Light is Illuminated"
4. "Check with Operator for Proper Eyewear"
5. "Restricted Area. Authorized Personnel Only"

Where multiple lasers are in use, the following are acceptable options for signage:

1. Indicate on the sign that there may be more than one wavelength in use and those entering are required to be informed by the laser user of the correct eyewear or precautions to follow;
2. Post one sign per laser;
3. List up to five lasers or wavelengths per sign; or
4. List all lasers or wavelengths and have a means to indicate which are in present use.

All areas where unattended Class 3B or Class 4 lasers and laser systems operate shall have a laser warning sign posted containing the applicable signal word ("WARNING" for Class 3B and "DANGER" for Class 4) and appropriate instructions regarding the hazards of entry into the space when an operator is not present.

All Class 2, Class 2M, Class 3R, Class 3B or Class 4 lasers and laser systems shall have a label conspicuously affixed to the laser housing or control panel. Such labels should be placed on both the housing and control panel if they are separated by more than two meters. The label shall include:

1. The class of the laser or the laser system
2. The emitted wavelength, pulse duration (if applicable), and the maximum output power
3. Precautionary statement

All Classes of lasers or laser systems with removable protective housings that have no safety interlocks, and which can be removed or displaced during operation, maintenance, or service shall have a label conspicuously affixed to the laser housing to indicate the hazard of the enclosed laser.

Laser manufacturers are required to label their equipment in accordance with the Federal Laser Product Performance Standard.
*NOTE: Per CDRH's *Laser Notice 53,* for lasers too small for labels (i.e. diodes), the label may be placed on the packaging or manual. Retain these items for inspection.

Contact the LSO for labeling guidance if the laser was not labeled by the manufacturer, or was built or modified in the laboratory.

All warning signs and labels shall be in accordance with ANSI Z136.1-2022. Labeling of laser equipment in accordance with the Federal Laser Product Performance Standard or the IEC 60825-1 standard may be used to satisfy the labeling requirements of ANSI Z136.1. PowerPoint templates that can be used to create ANSI Z136.1-2022 compliant warning signs and labels are available on the EHS website.

Table 3. ANSI Z136.1-2022 Summary of Protective Equipment Labeling

Laser Protective Eyewear	OD and wavelength
Viewing Windows and Display Screens	OD, wavelength, and exposure time
Facility Windows	OD, wavelength, and exposure time
Laser Protective Barrier	Threshold limit and exposure time
Collecting Optics Filters	OD, wavelength, and threshold limit
NOTE: Labeling is only required when windows, filters, or barriers are not sold as an integral part of the product.	

Table 4. ANSI Z136.1-2022 Control Measures: Special Considerations and Warning Signs

Special Considerations/ Warning Signs	Class 1/1M	Class 2/2M	Class 3R	Class 3B	Class 4
Laser Optical Fiber Transmission Systems	Required if MPE exceeded	Required if MPE exceeded	Required if MPE exceeded	Required	Required
Laser Robotic Automated Installations				Required Analysis of Nominal Hazard Zone Required	Required Analysis of Nominal Hazard Zone Required
Laser Controlled Area Warning Signs				Required	Required

17. PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) is required whenever Maximum Permissible Exposure levels to laser radiation may be exceeded. All PPE must be properly stored and inspected before use to verify that it is not defective and is suitable for the laser systems in use.

Protective eyewear is required to be worn whenever Class 3B and Class 4 laser systems are in use. Protective eyewear may also be required for Class 2 and Class 3R laser systems where intentional long term (> 0.25 seconds) or direct viewing is required. Protective eyewear must be ANSI approved and clearly labeled with the

wavelengths and optical densities for which the minimum level of protection is provided. Because laser eyewear may only offer protection over a narrow range of wavelengths, eyewear designed for use at one wavelength may provide little or no protection at another wavelength. This specificity can be a problem in situations where multiple wavelengths and/or unfiltered harmonics are present in addition to the primary beam (e.g. unfiltered frequency doubled Nd:YAG laser pointers that are frequency doubled from a 1064 nm infrared beam to a 532 nm visible green beam). Laser eyewear selection should be made in consultation with a reputable eyewear manufacturer and the LSO or a DLSO.

Considerations when purchasing eyewear:

- Manufacturers' recommendations on shelf life, storage conditions, cleaning, and use
- The damage threshold
    - Typical damage thresholds for CW lasers fall between 500-1000 W/cm^2 for dielectric coated glass, 100-500 W/cm^2 for uncoated glass, and 1-100 W/cm^2 for plastics
- High-powered lasers may exceed the damage threshold and may cause significant skin injury to the face if the beam is not confined to the eyewear
- Both glass and polycarbonate materials have been reported to undergo saturable absorption, which reduces the OD of the eyewear, thus reducing the protection provided. Pulsed lasers and lasers with high peak irradiance are the most common causes

See Attachment 2 for the ANSI Eyewear Selection Chart.

In addition to eye protection, unenclosed UV laser systems may require the use of protective clothing to guard against UV skin exposures above occupational exposure limits. IR lasers over 1400 nm may require the use of fire-resistant protective clothing to protect from heat stress.

Table 4. ANSI Z136.1-2022 Personal Protective Equipment

PPE	Class 1/1M	Class 2/2M	Class 3R	Class 3B	Class 4
Protective Eyewear				Required	Required
Skin Protection				Recommended	Recommended
Protective Clothing				Recommended	Recommended

18. NON-BEAM HAZARDS

Non-beam hazards are those hazards not related to actual exposure to laser radiation. These can include physical, chemical, and biological agents. These hazards must be reviewed and addressed in the SOP for the laser operation.

18.1. Electrical Hazards

Some lasers use high-voltage (>50V) power supplies, large capacitors, or capacitor banks that present a lethal shock hazard. Additional hazards of electrical equipment include resistive heating and electric spark ignition of flammable materials. All electrical equipment, electrical work, etc. must meet electrical safety, lockout tag out and other applicable requirements. Refer to the Electrical Safety Program at ehs.unm.edu.

The following potential electrical problems have been frequently found during laser facility audits:

- Uncovered and improperly insulated electrical terminals
- Hidden "power-up" warning lights
- Lack of personnel trained in current cardiopulmonary resuscitation practices, or lack of refresher training
- "Buddy system" or equivalent safety measure not being practiced during maintenance and service
- Failure to properly discharge and ground capacitors
- Non-earth grounded or improperly grounded laser equipment
- Non-adherence to the OSHA lock-out standard (29 CFR 1910.147)
- Excessive wires and cables on floor that create fall or slip hazards

18.2. Compressed Gases

Hazardous gases, such as fluorine and hydrogen chloride in excimer lasers, may be used in laser activities as part of the experiment or inherent to the laser system. All compressed gases having a hazardous material information system (HMIS) health, flammability, or reactivity rating of 3 or 4 shall be contained in an approved and appropriately exhausted gas cabinet that is alarmed with sensors to indicate potential leakage. Refer to the UNM Chemical Hygiene Plan at ehs.unm.edu.

18.3. Laser Dyes and Solvents

Dyes used in dye lasers are often highly toxic or carcinogenic organic chemicals that are dissolved flammable solvents. These materials require special handling to avoid potential personnel exposures above occupational exposure limits, fires, and chemical spills. These materials must be handled in a manner that complies with applicable local, state and federal regulations. They must be prepared inside a chemical fume hood and Safety Data Sheets must be available for all dyes and solvents in use. Contact EHS for guidance on how to handle

hazardous chemicals.

18.4. Laser Generated Air Contaminants

Air contaminants may be generated when certain Class 3B and Class 4 laser beams interact with materials. When target irradiance reaches approximately 10^7 W/cm^2, target materials including plastics, composites, metals and biological tissues may liberate carcinogenic, toxic and noxious airborne contaminants. Any laser operation that creates visible smoke or a plume must be evaluated by EHS to determine the need for local exhaust ventilation. In some cases, respiratory protection may also be required.

18.5. Plasma Radiation

Interactions between very high power (~10^{12} W/cm2) laser beams and target materials may produce a plasma, which in turn generates "blue light" and UV emissions that pose an eye and skin hazard. Similarly, targets heated to very high temperatures (e.g. in laser welding and cutting) emit an intense light. The PI must ensure adequate control measures are in place and addressed in the SOP for such operations

18.6. UV and Visible Radiation

Laser discharge tubes and pump lamps may generate sufficient UV and visible radiation to pose an eye and skin hazard. Short wavelength UV radiation may also produce ozone that will need to be exhausted from the area.

18.7. Ionizing Radiation (X-rays)

Electronic components of lasers systems such as X-rays could be produced from two main sources: high voltage vacuum tubes of laser power supplies such as rectifiers and thyratrons and electric discharge lasers. Any power supplies that require more than 15 kilovolts may produce enough x-rays to be a health concern. Consult HSC Radiation Safety (925-0743) for review and control of such hazards.

19. Optical Fibers

Optical fibers or optical fiber cables attached to Class 3B and Class 4 lasers or laser systems should not be disconnected prior to termination of transmission of the beam into the fiber. Always work with fiber optics as if they were active or live.

When power termination is not possible and laser radiation above the MPE can be made accessible by disconnection of a connector, the connector shall bear a label or tag bearing the words “Hazardous Laser Radiation when Disconnected”, or a similar message. Disconnection in this case shall only take place in a laser controlled area (LCA).

If connection or disconnection is only possible with the use of a specific tool, this is equivalent

to an interlocked system.

Small lengths or particles of optical fiber material may pose a risk of irritation or injury, particularly when cleaving fibers during splicing or connectorizing operations. Personnel should be trained in glass particle hazards. The use of a lab coat or disposable apron is recommended when cutting or splicing fibers. Always wear safety glasses when performing work directly on optical fibers due to the hazards from glass particles. The use of protective guards or shields should be considered, especially during cleaving operations. Discarded pieces of fiber should be collected in a suitable container to avoid subsequent embedding in clothing or skin. If a container is not available the pieces should be wrapped in tape and placed in a plastic bag.

20. Operating Procedures

Written operating procedures are required for Class 3B and Class 4 lasers or laser systems. These written procedures must be reviewed and approved by the LSO. As applicable, the written procedures should address normal operations, alignment and service procedures. Written procedures must include the following sections.

- Identification of the laser and operating characteristics
- Beam and non-beam hazards associated with the laser
- Control measures including engineering controls, administrative controls, and personal protective equipment
- Applicable beam alignment and service procedures
- Training requirements
- Emergency procedures
- Approved personnel
- Visitor requirements
- A template is included as Attachment 1
- A template for Alignment Procedures is included as Attachment 3

21. Alignment Procedures

Alignment of Class 3B and Class 4 laser optical systems shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of the beam, does not expose the eye or skin to a level above the applicable MPE.

Alignments should only be performed by those who have received laser safety training and appropriate on the job training and are aware of any non-beam hazards that may arise.

The following precautions should be taken during beam alignment:

- Exclude unnecessary personnel from the laser area

- Whenever possible, use low-power visible lasers for path simulation of higher-power visible or invisible lasers
- Wear protective eyewear and clothing appropriate for the laser being aligned
- When aligning invisible (and in some cases visible) beams, use beam display devices such as image converter viewers or phosphor cards to locate beams
- Whenever possible the use of remote viewing devices and automated devices should be considered
- Perform alignment tasks on high-powered lasers at the lowest possible power level
- Use a shutter or beam block to block beams at their source except when actually needed
- Use a laser-rated beam block to terminate beams down range of the optics being aligned
- Use beam blocks and/or barriers in conditions where beams could stray into areas with uninvolved personnel
- Place beam blocks behind mirrors to terminate beams that might miss the mirrors during alignment
- Locate and block all stray reflections before proceeding to the next component or section
- Ensure all beams and reflections are properly terminated prior to operation
- For enclosed Class 1 lasers, post area warning signs during alignment procedures
- Replace any enclosures or beam blocks removed during the process

22. OUTDOOR LASER OPERATIONS

Laser experiments that will involve the use of lasers in navigable airspace shall/should be coordinated with the Federal Aviation Administration (FAA) and U.S. Space Command in the planning stages to ensure proper control of any hazard to airborne personnel and equipment. Refer to the latest versions of FAA Order JO 7400.2J and ANSI Z136.6 for additional information.

Only Class 1 lasers or laser systems shall be used for outdoor public demonstrations, displays, or light shows in unsupervised areas. Any outdoor use of Class 3B or Class 4 lasers in unsupervised areas involving the general public requires a written variance issued by the U.S. Food and Drug Administration, Center for Devices and Radiological Health.

23. PROCEDURES IN CASE OF ACCIDENT/INJURY

- If possible, shut down the laser. DO NOT alter the setup
    - Inform others that the system has been shut down and is not to be used until cleared by the LSO
- Those unaffected should ensure the safety of those in the lab (first aid, evacuation, etc.) and call for help
- Seek medical assistance – CALL 911 for Severe Injuries (bleeding, unconsciousness, burns, confusion)

a. University employees should go to

- Employee Occupational Health Services (EOHS) -(505) 272-8034

b. Students should go to

- Student Health Services - (505) 277-7810

c. After normal business hours go to the emergency room or urgent care

- Inform your PI and Department Safety Officer (where applicable) as soon as possible
- An incident report should be filed at Accident, Incident & Spill Reporting :: Environmental Health & Safety | The University of New Mexico (unm.edu) as soon as possible by the affected party or the PI

24. LASER DECOMMISSIONING AND DISPOSAL

If a laser is no longer going to be actively used, but kept for parts or other reasons, it should be decommissioned. This will remove it from inventory and it will no longer be inspected by EHS.

- Cut the electrical cord; or
- Remove other means of activating the laser; followed by
- De-energizing the laser; and
- Drain all fluids (contact EHS for waste disposal if the fluids are hazardous).
- Notify the LSO.

There are four basic methods for the disposal of excess or unusable laser systems at UNM. In all cases, consult with UNM Surplus Property and Environmental Health and Safety to determine current University requirements.

- Donations. Ensure that the laser system complies with all applicable product safety standards such as the Federal Laser Product Performance Standard and electrical codes

The donor is required to provide adequate safety instructions for the operation and maintenance of the laser system to the recipient. All donations must also comply with UNM policies regarding the donation of University equipment. Export controls may also apply to external donations

- Trading in the laser system for credit towards the purchase of a new laser or re-selling the laser system to a recycler
- Decommissioning followed by disposal. Contact the manufacturer to see if they will take it for disposal, refurbishment, or parts
- Destruction and disposal of the laser system
- Notify the LSO

The last two methods of disposal may be subject to waste disposal restrictions due to hazardous materials contained in the components of the laser system such as mercury switches, oils, and laser media containing hazardous chemicals. Contact EHS for guidance on disposal of hazardous materials.

24.1. Considerations

- Lasers manufactured prior to 2006 contain lead in the circuit boards and must be disposed of as electronic waste
- Laser systems with high voltage capacitor systems pose a risk of electrical shock. Standard capacitor safety must be followed
- Dye Lasers
    - Liquid dyes and solvents must be considered carcinogenic or mutagenic
    - Utilize PPE (goggles, apron, gloves) to rinse pump containers
    - Rinse several times with methanol and then with water until fluid is clear
    - Dispose of fluid as hazardous waste through EHS: https://ehs.unm.edu/waste-management/index.html
- Gas Lasers
    - Metal plasma tubes may contain Beryllium which can form a hazardous dust if the tube is broken
    - For glass: crack one end of the tube in a fume hood or well-ventilated area and dispose of in the trash
    - For metal: dispose of through EHS
- Solid State and Rod Lasers

  - The circuit boards may contain lead and the diodes may contain Gallium Arsenide. Consult with EHS for disposal

- Diode/Semiconductor Lasers
  - For individual units, break the unit while wearing protective eyewear and gloves and dispose of in the trash
  - For multiple units (10 or more), dispose of through EHS. Diodes contain gallium arsenide and may be hazardous in large enough quantities
  - If part of a fiber optic system, wear protective eyewear and gloves and cut the fiber near the diode. Dispose of the fiber in a sharps container

25. EXPORT CONTROLS

Contact UNM Export Control for guidance and details

There are federal laws that prohibit the unlicensed export of certain commodities or information for reasons of national security of protections of trade. A laser of any classification may be subject to these regulations due to the laser's type or application. Many lasers do not require government licenses. "License controlled" exports may be found at:

1. The Department of Commerce's Export Administration Regulations (15CFR730-774)
2. The Department of State's International Traffic In Arms Regulations (22CFR120-130)
3. The Treasury Department's Office of Foreign Assets Control (31CFR500-599)

26. ATTACHMENTS

1. Job Hazard Analysis/SOP Template
2. Laser Eyewear Protection Selection Chart
3. Alignment SOP Template

ATTACHMENT 1

Job Hazard Analysis/SOP Template

ENVIRONMENTAL HEALTH & SAFETY

LASER STANDARD OPERATING PROCEDURE

ONLY STAFF WHO HAVE COMPLETED UNM'S LASER SAFETY TRAINING AND (Department-Specific Training) AND ARE AUTHORIZED BY (Name) SHALL OPERATE THIS LASER.

Building Name:	**Lab Name/Room Number:**
PI:	**Phone Number/Email:**
Facility Manager:	**Phone Number/Email:**
Emergency Contact:	**Phone Number/Email:**
□ Emergency Contact Information Posted on Door?	
Laser Safety Officer (EHS):	**Phone Number/Email:**
Department LSO:	**Phone Number/Email:**
Date:	**Dept/College:**
Description of Laser Application(s): ☐ Diagram of lab with laser location(s) attached ☐ Photos of laser(s) in lab attached	

Laser Specifications (Please see Appendix A if you have more than 3 lasers)			
Location of Owner's Manual(s):			
Registered with EHS? ☐ Yes ☐ No Please register laser(s) at https://ehs.unm.edu/laboratory-safety/laser-safety.html			
	Laser 1	**Laser 2**	**Laser 3**
Laser Class	☐ 3B ☐ 4	☐ 3B ☐ 4	☐ 3B ☐ 4
Laser Type			
System	☐ Individual ☐ Embedded ☐ Custom-built	☐ Individual ☐ Embedded ☐ Custom-built	☐ Individual ☐ Embedded ☐ Custom-built
Manufacturer			
Model			
Serial Number			
Continuous Wave or Pulsed	☐ CW ☐ Pulsed	☐ CW ☐ Pulsed	☐ CW ☐ Pulsed
Pulse Length			
Maximum Power			
Frequency			
Wavelength in Use			
Diameter or Dimensions			

Beam Path *Partially Enclosed – some of the beam path is enclosed and some of it is open	☐ Open	☐ Fully Enclosed	☐ Open	☐Fully Enclosed	☐ Open	☐ Fully Enclosed
	☐ Partially Enclosed	☐ Beam between sitting & standing height	☐ Partially Enclosed	☐ Beam between sitting & standing height	☐ Partially Enclosed	☐ Beam between sitting & standing height
Beam Divergence						

Beam Hazards	
☐ Unenclosed Beam/Access to Direct or Scattered Light Control(s):	☐ UV Radiation/Blue Light Exposure Control(s):
☐ Reflective Material in Beam Path Control(s):	☐ Other: Control(s):
☐ Other: Control(s):	☐ Other: Control(s):
Non-Beam Hazards	
☐ Toxic materials (Dyes, solvents, etc.): Control(s):	☐ High Voltage Control(s):
☐ Compressed Gases: Control(s):	☐ Flammable Liquids: Control(s):
☐ Flammability from Laser Exposure Control(s):	☐ Laser-generated Air Contaminants: Control(s):
☐ Cryogenic Materials: Control(s):	☐ Hazardous Waste: Control(s):
☐ Noise Control(s):	☐ Other: Control(s):
☐ Other: Control(s):	☐ Other: Control(s):
☐ Other: Control(s):	☐ Other: Control(s):

Engineering Control Measures (Please see Appendix B if you have more than 3 lasers)						
	Laser 1		**Laser 2**		**Laser 3**	
Protective Housing	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Interlocks on Removable Protective Housing	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Emergency Stop	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Key Control	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

Viewing Windows, Display Screens and Collecting Optics	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
***MPE**			
***Nominal Hazard Zone for Fully Open Beam Path**			
***Nominal Hazard Zone for Limited Open Beam Path**			
Beam Stops/Attenuators	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Laser Radiation Emission Warning	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Class 4 Laser Controlled Area	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Entryway Controls	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Protective Barriers and Curtains	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Grounding	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Laser Secured to Base	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No

Explanation for any "No" Answers Above

*MPE and NHZ can be calculated at https://lasersafetyu.kentek.com/easy-haz-laser-hazard-software-basic-web-version

Administrative Controls			
Output Emission Limitations	☐ Yes	☐ No	☐ N/A
UNM Learning Central Laser Training Records	☐ Yes	☐ No	
Laser-Specific Training Records	☐ Yes	☐ No	
Authorized Personnel Records	☐ Yes	☐ No	
Outdoor Control Measures	☐ Yes	☐ No	☐ N/A
Alignment Procedures	☐ Yes	☐ No	☐ N/A
Warning Signs on Door	☐ Yes	☐ No	

Laser Safety Eyewear
1. Appropriate laser protective eyewear must be worn within the nominal hazard zone at all times when working with Class 3B and/or Class 4 lasers and whenever there is a reasonable likelihood of exposure to a harmful level of laser radiation. 2. Eyewear should be clean with no scratches. 3. Inspect prior to each use.
Storage:

Manufacturer	Wavelength	Emission Type	OD*

*OD can be calculated at https://www.lia.org/evaluator/od.php

Other Personal Protective Equipment		
☐ Gloves:	☐ Lab Coat	☐ Hearing Protection
☐ Respiratory Protection:	☐ Other:	☐ Other:

Operating Procedures
Remove personal jewelry. Watches, rings etc. act as reflectors. When entering a laser lab, remove anything that may pose a reflection hazard. This is to protect you and your co-workers. Enter equipment-specific operating procedures here. Be sure to include Pre-operation, Startup, Shutdown Procedures, and Lab-Specific Emergency Procedures. Also include Calibration and Visitor procedures if applicable.

Emergency Actions	
In the event of an emergency, it is important to understand the control measures below:	
Fire	✓ Switch off the power supply to the laser if it is safe to do so. ✓ Do not put yourself in danger. ✓ Activate the fire alarm. ✓ As long as it does not compromise your safety, you can attempt to extinguish the fire with the appropriate equipment. ✓ Evacuate to an assembly point.
Laser Eye Injury	✓ If an accident occurs, seek help from someone nearby. ✓ Press the emergency button to disable laser(s). ✓ Do not hesitate to call 911 if the injury is severe. ✓ Keep the injured person in an upright position. ✓ Report to Employee Occupational Health Services (EOHS) or Student Health Services (SHAC) even if you believe the injury is minor. ✓ If the exposure occurs after hours, employees and students should seek medical attention at a hospital emergency room. ✓ Report to your supervisor as soon as you are able.
ALL ACCIDENTS/INCIDENTS MUST BE REPORTED TO THE LASER SAFETY OFFICER AND ENVIRONMENTAL HEALTH & SAFETY.	
Fire or Medical Emergency: 911	**Life-Threatening Emergency, After Hours, Weekends and Holidays: 911**

Non-Life Threatening Emergency: UNM Police: (505)277-2241	**Environmental Health & Safety:** (505) 277-2753
EOHS: (505) 272-8034	**SHAC:** (505) 277-7810

Vendor Resources					
Company	**Phone**	**Website**	**Contact**	**Phone**	**Email**

References
UNM *Laser Safety Program,* which is available on the EHS website.

Signatures	
Principal Investigator SOP Approval	
Signature:	**Date:**
Printed Name/Title:	
Laser Safety Officer SOP Approval	
Signature:	**Date:**
Printed Name/Title:	

I have read and understand the content of this Standard Operating Procedure:

Name	Signature	Date

APPENDIX A

Additional Laser Specification Sheets

Laser Specifications						
	Laser ___		**Laser ___**		**Laser ___**	
Laser Class	☐ 3B	☐ 4	☐ 3B	☐ 4	☐ 3B	☐ 4
Laser Type						
System	☐ Individual ☐ Embedded ☐ Custom-built		☐ Individual ☐ Embedded ☐ Custom-built		☐ Individual ☐ Embedded ☐ Custom-built	
Manufacturer						
Model						
Serial Number						
Continuous Wave or Pulsed	☐ CW	☐ Pulsed	☐ CW	☐ Pulsed	☐ CW	☐ Pulsed
Pulse Length						
Maximum Power						
Frequency						
Wavelength in Use						
Diameter or Dimensions						
Beam Path	☐ Open ☐ Partially Enclosed	☐ Fully Enclosed ☐ Beam between sitting & standing height	☐ Open ☐ Partially Enclosed	☐Fully Enclosed ☐ Beam between sitting & standing height	☐ Open ☐ Partially Enclosed	☐ Fully Enclosed ☐ Beam between sitting & standing height
Beam Divergence						

APPENDIX B

Additional Engineering Control Sheets

Engineering Control Measures						
	Laser ____		Laser ____		Laser ____	
Protective Housing	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Interlocks on Removable Protective Housing	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Emergency Stop	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Key Control	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Viewing Windows, Display Screens and Collecting Optics	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
***MPE**						
***Nominal Hazard Zone for Fully Open Beam Path**						
***Nominal Hazard Zone for Limited Open Beam Path**						
Beam Stops/Attenuators	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Laser Radiation Emission Warning	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Class 4 Laser Controlled Area	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Entryway Controls	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Protective Barriers and Curtains	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Grounding	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Laser Secured to Base	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

Explanation for any "No" Answers Above

*MPE and NHZ can be calculated at https://lasersafetyu.kentek.com/easy-haz-laser-hazard-software-basic-web-version

ATTACHMENT 2

Laser Eyewear Protection Selection Chart

ENVIRONMENTAL HEALTH & SAFETY

Laser Eye Protection Selection Chart

For Wavelengths between 400 and 1400 nm

Q-Switched (1ns – 0.1ms)		**Non-Q-Switched (0.4ms – 10ms)**		**Continuous Wave Momentary (0.25s – 10s)**		**Continuous Wave Long-term Staring (>3 hours)**		**Attenuation**	
Max Output Energy (J)	Max Beam Radiant Exposure ($J\text{-}cm^{-2}$)	Max Output Energy (J)	Max Beam Radiant Exposure ($J\text{-}cm^{-2}$)	Max Power Output (W)	Max Beam Irradiance ($W\text{-}cm^{-2}$)	Max Power Output (W)	Max Beam Irradiance ($W\text{-}cm^{-2}$)	Attenuation Factor	Optical Density (OD)
10	20	100	200	*	*	*	*	10^{8}	**8**
1	2	10	20	*	*	*	*	10^{7}	**7**
10^{-1}	2×10^{-1}	1	2	*	*	1	2	10^{6}	**6**
10^{-2}	2×10^{-2}	10^{-1}	2×10^{-1}	*	*	10^{-1}	2×10^{-1}	10^{5}	**5**
10^{-3}	2×10^{-3}	10^{-2}	2×10^{-2}	10	20	10^{-2}	2×10^{-2}	10^{4}	**4**
10^{-4}	2×10^{-4}	10^{-3}	2×10^{-3}	1	2	10^{-3}	2×10^{-3}	10^{3}	**3**
10^{-5}	2×10^{-5}	10^{-4}	2×10^{-4}	10^{-1}	2×10^{-1}	10^{-4}	2×10^{-4}	10^{2}	**2**
10^{-6}	2×10^{-6}	10^{-5}	2×10^{-5}	10^{-2}	2×10^{-2}	10^{-5}	2×10^{-5}	10	**1**

* Eyewear is not recommended as a control at these levels. These levels could damage or destroy the attenuating material used in the eyewear. Skin protection is required at these levels.

OD can be calculated at https://www.lia.org/evaluator/od.php

September 10, 2021

ATTACHMENT 3

Alignment SOP Template

ENVIRONMENTAL HEALTH & SAFETY

Laser Safety Program

LASER ALIGNMENT STANDARD OPERATING PROCEDURE

ONLY STAFF WHO HAVE COMPLETED UNM'S LASER SAFETY TRAINING AND LASER-SPECIFIC ALIGNMENT TRAINING AND ARE AUTHORIZED BY (Name) SHALL ALIGN THIS LASER.

Building Name:		**Lab Name/Room Number:**	
PI:		**Phone Number/Email:**	
Emergency Contact:		**Phone Number/Email:**	
Laser Safety Officer (EHS):		**Phone Number/Email:**	
Department LSO:		**Phone Number/Email:**	
During Alignment			
Location of Owner's Manual(s):			
Laser Class	☐ 3B ☐ 4	**Serial Number**	
Nominal Hazard Zone*		**Laser Controlled Area?**	☐ Yes ☐ No
Beam Controls	☐ Viewer(s)	☐ Card(s)	☐ Curtain(s)
	☐ Block(s)	☐ Other:	☐ Other:
Comments:			
*MPE and NHZ can be calculated at https://lasersafetyu.kentek.com/easy-haz-laser-hazard-software-basic-web-version			

Personnel Authorized to be in Laser Controlled Area During Alignment	

Laser Safety Eyewear

1. Appropriate laser protective eyewear must be worn within the nominal hazard zone at all times when working with Class 3B and/or Class 4 lasers and whenever there is a reasonable likelihood of exposure to a harmful level of laser radiation.
2. Eyewear should be clean with no scratches.
3. Inspect prior to each use.

Storage:

Manufacturer	Wavelength	Emission Type	OD*

*OD can be calculated at https://www.lia.org/evaluator/od.php

Other Personal Protective Equipment		
☐ Gloves:	☐ Lab Coat	☐ Hearing Protection
☐ Respiratory Protection:	☐ Other:	☐ Other:

Beam Alignment Procedures
Remove personal jewelry. Watches, rings etc. act as reflectors. When entering a laser lab, remove anything that may pose a reflection hazard. This is to protect you and your co-workers. Enter equipment-specific beam alignment procedures here.

Emergency Actions	
In the event of an emergency, it is important to understand the control measures below:	
Fire	✓ Switch off the power supply to the laser if it is safe to do so. ✓ Do not put yourself in danger. ✓ Activate the fire alarm. ✓ As long as it does not compromise your safety, you can attempt to extinguish the fire with the appropriate equipment. ✓ Evacuate to an assembly point.
Laser Eye Injury	✓ If an accident occurs, seek help from someone nearby. ✓ Press the emergency button to disable laser(s). ✓ Do not hesitate to call 911 if the injury is severe. ✓ Keep the injured person in an upright position. ✓ Report to Employee Occupational Health Services (EOHS) or Student Health Services (SHAC) even if you believe the injury is minor. ✓ If the exposure occurs after hours, employees and students should seek medical attention at a hospital emergency room. ✓ Report to your supervisor as soon as you are able.

ALL ACCIDENTS/INCIDENTS MUST BE REPORTED TO THE LASER SAFETY OFFICER AND ENVIRONMENTAL HEALTH & SAFETY.

Fire or Medical Emergency: 911	**Life-Threatening Emergency, After Hours, Weekends and Holidays: 911**
Non-Life Threatening Emergency: UNM Police: (505)277-2241	**Environmental Health & Safety:** (505) 277-2753
EOHS: (505) 272-8034	**SHAC:** (505) 277-7810

Signatures	
Principal Investigator SOP Approval	
Signature:	**Date:**
Printed Name/Title:	
Laser Safety Officer SOP Approval	
Signature:	**Date:**
Printed Name/Title:	

I have read and understand the content of this Standard Operating Procedure:

Name	Signature	Date