LASER SAFETY MANUAL

University of Nevada, Las Vegas

Responsible Office: Office of Radiological Safety
Department of Risk Management and Safety
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REVISION HISTORY

Rev. No.	Effective Date	Description of Revision
2	04/15/17	Revised to add a "Statement of Minimum Qualifications" (Form 7) for any visiting person, company or entity (Person) operating, or intending to operate a non-UNLV owned Class 3B or Class 4 laser on any UNLV property (see Section 3.7); and, to remove reference to the Radiation Safety Office cell phone.
1	10/26/15	Revised to add a “Revision History” page; to add an “Acronyms and Abbreviations” page; and to incorporate changes from ANSI Z136.1 (2007) being superseded by ANSI Z136.1 (2014)
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PREFACE

This Laser Safety Manual contains the policy, regulations, and procedures for the safe use of laser and certain other optical systems at the University of Nevada, Las Vegas. Although overall responsibility for laser safety rests with the University, basic responsibility for the protection of life and property must remain with the individual user of the laser and other optical systems. Thus, this individual must possess certain acceptable qualifications and follow designated policies and required procedures as outlined in this manual.

Changes to the Manual may occur as the program evolves. Such changes shall be approved by the Laser Safety Advisory Committee, shall not conflict with ANSI Z136 standards, and shall not diminish the effectiveness of the UNLV Laser Safety Program.

Approved by : Brian Rowsell 3-31-2017

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WHY IS LASER SAFETY SO IMPORTANT?

YOUR EYES ARE IRREPLACEABLE!

Consider: You are reading these words using an anatomical marvel: the human eye. The primary hazard of laser radiation is eye damage, which can occur even at modest laser beam power. The most serious hazard--retinal damage--can happen in an instant: it will be immediate, irrevocable, and may be catastrophic. It is due to a laser beam entering the eye and being transmitted to the retina where it is absorbed, causing permanent, partial, or complete loss of vision. Even if vision improves, the high-resolution (fine detail) capability—necessary for example, for reading these words—may be gone, forever.

The reason even relatively low-power laser beams can cause such damage is that the eye focuses visible light on the retina by a factor of 100,000. The eye will also try to focus the light on the fovea, or central field of vision. Damage here will cause a large central blind spot. Damage to other sections of the retina will also produce a blind spot, it may cause hemorrhaging of blood vessels and a bloody haze, or floating spots. If off-center exposures damage the optic nerve, the result can be total blindness.

Visible light (400 to 700 nm in ANSI, but 380 to 780 nm by the Laser Institute of America) can be damaging to the retina, but Near-IR (780-1400 nm) can also be especially dangerous. It can be focused on the retina, but it's invisible, not detected. A soft but audible "pop" indicates the ablation of your retina.

HOW CAN I PROTECT MYSELF AND WORK SAFELY WITH LASERS?

1. **Know the Class and power of the laser: a Class 3B or Class 4 laser is capable of causing immediate and irreparable damage. A Class 3R laser can be hazardous and must be respected. The Classification is marked on commercial lasers; it may not be immediately obvious on a home-built or research laser. NEVER LOOK DIRECTLY INTO THE BEAM OF ANY LASER!**
2. **Pay attention to postings on doors and labels on instruments. ANSI postings and labels give appropriate warnings, protective eyewear requirements, and the Class of the laser. Read and heed such postings and labels.**
3. **Attend the training classes provided; read and follow the Manual and Standard Operating Procedures (SOPs).**
4. **Always remember that a laser laboratory holds many potential hazards. Make every effort to Think Safety and Work Safely. Keep diversions to a minimum. Do NOT allow yourself to become complacent. Go over your SOPs and read the manuals, this one and others. Re-read your emergency procedures, and ask yourself, "What would I do if—"**

Lasers are used constantly, most often safely and productively. Let your work add to that record.

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1.0 INTRODUCTION

The University of Nevada, Las Vegas (UNLV) makes all reasonable efforts to:

- Protect the health and safety of the University faculty, staff, students, and visitors to facilities where lasers are used.

- Provide safe work practices - academic, research, and administrative - for faculty, staff, students, and visitors to facilities where lasers are used.

- Provide training to faculty, staff, and students about the health and safety hazards associated with the use of lasers.

- Identify and correct laser use health and safety hazards and encourage faculty, staff, and students to report known hazards.

- Provide information and safeguards on campus regarding environmental hazards arising from laser operations at UNLV.

To help fulfill this University policy the Laser Safety Program has been developed to provide guidance for the safe use of lasers and laser systems. The Program and recommendations are based upon and will follow:

- ANSI Z136.1, "*American National Standard for Safe Use of Lasers*"

- The American Conference of Governmental Industrial Hygienists (ACGIH) 2006 "*Threshold Limit Values for Ultraviolet and Infrared Optical Radiation*."

To help facilitate this manual, the following list of Appendices has been provided:

- Appendix A: Acronyms and Abbreviations
- Appendix B: Definitions
- Appendix C: Common Types of Lasers
- Appendix D: Eyewear Selection Chart
- Appendix E: Laser and Optical Source Warning Signs
- Appendix F: Guidelines and Operation Procedures
- Appendix G: Other Programs Under the Purview of the UNLV RSO

1.1 SCOPE AND PURPOSE

This manual is designed to ensure the safe use of laser and certain other optical systems at UNLV. This manual applies to all faculty, staff, and students at UNLV that use lasers and certain other optical sources as well as to visitors to facilities where lasers are used.

Non-coherent sources in the visible, ultra-violet (UV) and infrared region (IR) are more difficult to assess and will be analyzed on a case by case basis by the UNLV Laser Safety

Officer. Class 1M, 2M, and some 3R (formerly Class 3A) laser users may require training, depending upon the application.

A variety of commercially available consumer, business, and industrial application lasers and optical radiation devices are exempted from the authorization requirements of this manual because of their common usage and negligible potential for hazardous exposure under conditions of normal use. Exempt products utilizing Classes 1, 1M, 2 and 2M laser devices, products, and systems include the following general categories of:

a. Laser printers;

b. Laser copiers;

c. Image scanners;

d. CD ROM players;

e. Bar code scanner, reader, and verifier units;

f. Classes 1, 1M, 2 and 2M laser devices and other products, except for those that allow access to covered or embedded classes of laser radiation during servicing operations, provided that the laser product is maintained as a Class 1 or Class 2 laser product through its useful life;

g. Service Group 1 (SG1) fiber optic devices/systems;

h. Laser Pointers (however, users of these devices will not use them in a manner which is inconsistent with their intended usage, such as lasing another person or an aircraft. Such activity will be subject to University disciplinary action and possibly criminal prosecution)).

Equipment Utilizing Non-laser Optical Devices, including the following general categories:

a. Photographic strobe units

b. High intensity discharge (HID) lamps utilized for facility lighting

c. Infrared radiation devices with accessible irradiance of less than 1 milliwatt per square centimeter (mW/cm^2)

d. Visible radiation devices with accessible luminance of less than 1 candela per square centimeter (cd/cm^2)

e. Ultraviolet radiation devices with accessible effective irradiance of less than 0.1 microwatt per square centimeter ($\mu W/cm^2$)

This policy applies to all University personnel per **Section 3.7** of this document.

2.0 LASER CLASSIFICATION

The ANSI Z136.1 standard was updated in 2007; however, remained mostly the same for the 2014 revision. Lasers purchased prior may be labeled with the earlier hazard classes. Changes made to the standard include the following:

Previous ANSI Standard hazard classes	ANSI Z136.1-2014 hazard classes
1	1/1M
2	2/2M
3A(most laser pointers)	3R
3A (expanded-beam lasers)	3R
3B	3B
4	4

Note: where M stands for Magnification and R stands for Reduced or Relaxed Requirements.

2.1 Class 1 and 1M

These are low-power lasers and laser systems that cannot emit radiation levels greater than the maximum permissible exposure (MPE). **Class 1** lasers and laser systems are incapable of causing eye damage under normal operating conditions. An example of this type of laser is the laser used in a compact disc player.

Class 1M laser systems are incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or a telescope (collimated beam) and exempt from any control measures other than to prevent potentially hazardous optically aided viewing.

2.2 Class 2 and 2M

These are visible, low power lasers and laser systems that emit radiation in excess of the MPE. **Class 2** lasers are incapable of causing eye damage unless they are viewed directly for an extended period. Normal human aversion responses will usually prevent damaging exposure. An example of a Class 2 laser is the laser used in the supermarket checkout counter.

Class 2M laser systems emit in the visible portion of the spectrum (0.4 to 0.7 μm) and eye protection is normally afforded by the aversion response for unaided viewing. However, Class 2M laser systems are potentially hazardous if viewed with certain optical aids.

2.3 Class 3R and 3B

These are medium power lasers and laser systems capable of causing eye damage with short duration (<0.25 sec.) exposure to the direct or reflected beam, usually reflected from specular (shiny, mirror like) surfaces. **Class 3R** laser systems are potentially hazardous under some direct and specular reflection viewing condition if the eye is

appropriately focused and stable, but the probability of an actual injury is small. This laser will not pose either a fire hazard or diffuse-reflection hazard. (Most lasers formerly labeled Class 3A will fall into the Class 3R.) The higher power **Class 3B** lasers may be capable of producing a hazardous reflection from diffusely reflecting surfaces (such as painted walls, white paper, etc.).

An example of a Class 3B laser is the Continuous Wave (CW) Argon laser at 0.488um with Radiant Power of 0.5 Watt or less.

2.4 Class 4

These are high power lasers and laser systems capable of causing severe eye damage with short duration (<0.25 sec.) exposure to the direct, specularly reflected, or diffusely reflected beam. **Class 4** lasers and laser systems are also capable of causing severe skin damage and igniting flammable and combustible materials. An example of a Class 4 laser is the Argon laser (CW) at 0.488 um with Radiant Power of greater than 0.5 Watt.

2.5 Embedded Lasers

Lasers are often embedded in laser products or systems with a lower hazard class. When the laser system is used as intended, the controls for the system's class apply. When the system is opened (e.g. for service or alignment) and the embedded laser beam is accessible, a temporary control area must be established. The controls for the temporary control area must be based on the classification of the embedded laser. The Registered Laser User and/or Laser Safety Officer must determine adequate controls.

Common types of lasers can be found in **Appendix C** of this manual.

3.0 DUTIES AND RESPONSIBILITIES

3.1 Laser Safety Officer (LSO)

Procurement, possession, and use of controlled lasers and optical radiation devices (or simply controlled devices) under the purview of the UNLV Laser Safety Program require coordination and approval with the UNLV LSO located in the Risk Management and Safety Department (RMS). The LSO is responsible for:

- Development, implementation, and oversight of the UNLV laser and optical safety program by setting policy and procedures contained in this manual.
- Maintaining an accurate inventory to account for all **Class 3B** and **4** lasers.
- Reviewing and authorizing each Registered Laser User for use of laser and laser system in the user’s laboratory.
- Reviewing applications for use of controlled laser and optical sources.

- Evaluating potential hazards and laboratory installations.

- Establishing exposure limits by reviewing and applying the most current standards; this is an on-going process which will change as standards are revised.

- Conducting hazard evaluations for each Class 3B and Class 4 laser and laser system.

- Evaluating and recommending personal protective equipment including laser protective eyewear and UV protective equipment.

- Approving standard operating procedures (SOPs), alignment procedures and other procedures that may be subject to administrative and procedural controls.

- Providing laser safety training.

- Providing ANSI approved warnings signs and labels.

- Enforcing policy and procedures contained in this manual by performing periodical audits and inspections of laser use facilities.

- Investigating accidents and incidents.

- Establishing enforcement actions against users who are in non-compliance with the policy requirements and have not made an attempt to remedy the non-compliance issue(s) in a timely manner.

3.2 Laser Safety Advisory Committee (LSAC)

The LSAC is established as a self-governing body to review as needed the safe use of lasers and laser systems at UNLV. The LSAC acts in an advisory capacity to the LSO and UNLV Administration.

The LSAC provides consultation to the LSO in providing the following services to the constituents of the UNLV Laser Safety Program:

- **Satisfying Regulatory Requirements**

  The Laser Safety Program is conducted under the *General Duty Clause, Section 5* (a) (1) of the Occupational Safety and Health Act: to provide employment free from recognized hazards which could cause serious physical harm. These conditions are also regulated under 29 CFR 1910.132 (*Face and Eye Protection*); 29 CFR 1910.147 (*Lock Out – Tag out Standard*); 29 CFR 1910.134 (*Respiratory Protection Standard*); 29 CFR 1926.102 (eye protection related to construction lasers) and 29 CFR 1926.54 (lasers in construction).

- **Ensuring a Safe and Healthful Working Environment**

  The UNLV Laser Safety Program is guided by ANSI Z136.1, "*American National Standard for Safe Use of Lasers*"; ANSI Z136.3, "*Safe Use of Lasers in Health Care Facilities*"; and, ANSI Z136.8, "*American National Standard for Safe Use of Lasers in Research, Development, or Testing*".

- **Minimizing Damage to the Facilities and Loss of Equipment**

  Pre-installation evaluation of facilities and a Safety Checklist are to be utilized.

- **Training and Educating Laser Users**

  The Registered Laser User must demonstrate the adequacy of training programs for all laser users. These training programs extend beyond laser users and include training or instruction for all individuals who may enter areas where lasers are used

- **Providing Assurance to Non-laser Workers**

  The laser safety program must establish and maintain sufficient credibility to answer questions and alleviate fears of emergency personnel, contractors, consultants, members of the general public, and family and friends of students and employees.

- **Providing Public Relations**

  Laser experts on the committee may be called upon to cooperate with the News and Public Information Office to educate the public about measures taken to ensure the safe and controlled uses of lasers.

- **Participating in Administrative Responsibilities and Budgetary Requirements**

  The LSAC provides a forum on the cost and benefit of safety activities required of the users, the LSO, and supporting staff.

<u>The Committee must meet the following administrative requirements:</u>

- Membership must consist of at least five (5) individuals and must include: the LSO, Registered Laser Users, and a representative of RMS who is neither a Registered Laser Users nor an LSO. Other members may be included as the Committee deems appropriate.

- To establish a quorum and to conduct business, at least one-half of the Committee's membership, but not less than four (4) must be present, including the LSO and the RMS representative.

- The minutes of each Laser Safety Advisory Committee meeting must include:

    - The date of the meeting;
    - The members present;
    - The members absent;
    - Summary of the deliberations and discussions;
    - Recommended actions and the numerical results of all ballots

- The LSO must provide each member with a copy of the meeting minutes, and retain one copy for the permanent record.

To oversee the use of lasers, the Committee must:

- Review all incidents involving lasers with respect to the cause and subsequent actions taken; and

- Review annually the laser safety program.

Note: Policy decisions are made by the LSO, responsible UNLV Administrative Authority, the LSAC, and any sub-committees serving in an advisory capacity only.

3.3 Registered Laser User (RLU)

The RLU is the person ultimately responsible for the safe use of the controlled laser devices under his or her control. Responsibilities of the RLU include:

- Contacting the LSO before acquiring a controlled device to receive authorization to safely use the proposed equipment; ideally this will be done during the proposal phase of a new grant or during the procurement phase of new equipment.

- Wearing appropriate personal protective equipment, attending training and ensuring that staff are trained, developing laboratory specific SOPs for their controlled device(s) and conducting all activities in a safe manner.

- Immediately contacting the LSO if an exposure incident has occurred or is suspected.

- Maintaining control and security of all controlled devices assigned to them.

- Maintaining required training records for each person working in their laboratory.

- Responding to information requests by the LSO in a timely manner.

- Notifying the LSO when a controlled device is decommissioned, sold or transferred from the University. It is important for the RLU to notify the LSO of the transfer of a controlled device to another RLU. Until the transfer is complete the responsibility of safely using the controlled device is the responsibility of the original RLU.

- Notifying the LSO of an extended absence that reduces the effective oversight of laboratory operations. If an extended absence is foreseen, an agreement must be reached with an appropriate substitute to oversee the use of the controlled devices while the RLU is absent

3.4 Individual Laser User (ILU)

ILUs are those workers who have received the appropriate laser safety and laboratory-specific/system-specific training and have demonstrated to the RLU's satisfaction that they can safely use the controlled devices. Designation as an ILU is applied after successful completion of LSO provided training. Responsibilities of the ILU include:

- Completing all required training before operating a controlled system.
- Working under the direct supervision of another knowledgeable individual user until competence in using the controlled system is demonstrated.
- Updating training if he/she transfers to a new RLU group or laboratory.
- Complying with all required SOPs established by the RLU for setting up, aligning, operating, and shutting down the controlled laser system.
- Reporting all accidents and exposures (known or suspected) to the RLU and to the LSO.

3.5 Other UNLV Employees and Students

A UNLV employee or student will not energize or work with or near a controlled laser system unless authorized to do so by an RLU and the LSO.

3.6 Visitors

Visitors, volunteers, and students not employed by the University must be provided protection from controlled laser systems at a level consistent with the requirements of this manual. Non-students under the age of 18 are prohibited from entering controlled areas covered by this policy unless supervised by the RLU, an ILU designated by the RLU, or the LSO.

3.7 Visitors/Vendors Class 3B/4 Laser Use on UNLV Campuses

Any visiting person, company or entity (Person) operating, or intending to operate a non-UNLV owned Class 3B or Class 4 laser on any UNLV property must have a credentialed LSO available, and a written laser safety program present and available at all times during laser operation at UNLV (see Laser Safety Form 7, current revision).

3.8 Laser Maintenance/Service

Only appropriately trained individuals shall perform laser maintenance or service. The RLU is responsible for ensuring that service personnel from outside vendors are appropriately trained and that the service is performed in accordance with UNLV policy. The RLU is responsible for informing the LSO before the service is performed. The RLU should advise service personnel that training documentation may be requested prior to work being allowed.

4.0 LASER ACQUISITION, TRANSFER AND DISPOSAL

4.1 Acquisition

The RLU must notify the LSO of all **Class 3B** or **Class 4** laser systems by submitting to the LSO a Laser System Registration Form for each laser system. A form must be re-submitted when significant modifications are made to the original laser system. The LSO will conduct a hazard evaluation of the laser work area and make necessary recommendations. Each officially registered laser system will be provided an inventory number affixed to the system.

4.2 Transfer

To meet laser safety regulations, a laser can be either transferred to another RLU, or the laser must be properly disposed. In either case, the LSO must be notified when a **Class 3B** or **4** laser is transferred.

4.2.1 Laser Transfer

If a laser system is being transferred to another RLU, the new RLU must complete a Laser System Registration Form. Moreover, the LSO must also be notified if the laser is to be transferred off-campus. In either case, a Laser Transfer/Disposal Form must be completed and submitted to the Radiation Safety Office indicating the following:

- Laser manufacturer
- Class of laser
- Make/Model
- Serial number
- Name of the RLU
- Current location of the laser system
- Name and address of the recipient
- Date of transfer

4.3 Disposal

The LSO must be notified prior to sale or disposal of a **Class 3B** or **4** laser and will coordinate with the RMS Hazardous Waste Program, as appropriate. Uncertified lasers (those not meeting federal standards) and lab-built lasers shall be rendered inoperative by the RLU before disposal. The LSO shall verify proper packaging and provide final authorization for disposal of a **Class 3B** or **4** laser.

4.3.1 Laser Disposal

The RLU must disable the laser device by either one of the two following methods:

- Remove all means of activating the laser (remove the power cord and power switches), or
- Destroy the laser hardware so it cannot be used again.

PRIOR TO SHIPPING A LASER SYSTEM FOR DISPOSAL, the RLU must:

- Review the manufacturer's laser system manual for any hazardous materials listed (if possible).
- Ensure the removal and proper disposition of any hazardous materials, such as mercury switches, oils, and other chemicals that are contained in the laser system (if applicable).

  Note: Consider the need to dispose of laser dyes and solvent solutions.
- Properly dispose of any chemical, biological, or radioactive wastes generated from the laser activities (if applicable).

  Note: The RMS Hazardous Waste Program can be contacted for assistance in the disposal process.

A "Laser Transfer/Disposal Form" must be completed and submitted to the Radiation Safety Office indicating that identified hazardous materials have been properly disposed and the laser system inactivated prior to disposal. This form must also include all the elements required under subsection 4.2.1.

5.0 CONTROL MEASURES

5.1 General Requirements

- **Class 1, 1M, 2,** and **2M** lasers may be used for the intended purposes of their manufacturer without restrictions. Any direct eye exposure to these types of lasers should be avoided.

- **Class 1M, 2M** and **3R** laser beams shall not be viewed with collecting optics (e.g. microscopes) unless the optical system is specifically designed and constructed to prevent eye exposure exceeding the applicable MPE.

- **Class 3R, 3B** and **4** lasers shall carry a warning label containing the laser classification, type, and other warnings required by ANSI Z136.1, or assigned an equivalent level by the builder. These requirements also apply to non-commercially built lasers that are used on the UNLV campus.

- **Class 3B** and **4** lasers must be registered with the LSO.

- Each **Class 3B** and **4** laser must be assigned to one or more RLU who is **(**are**)** responsible for safe storage and use of that laser. The LSO must be consulted whenever a laser is acquired, reassigned to a new RLU, transferred off-campus, or disposed. Please contact the LSO prior to initiating any of these activities.

- All laser users must complete training specific to the type of laser they operate. This requirement will be reviewed during laser safety audits or inspection.

- All lasers must be operated according to the applicable ANSI Z136.1 safety standards and in a manner consistent with safe laser practices. Laser Safety SOPs are required for certain **Class 3B** lasers and for all **Class 4** lasers.

- Each **Class 3B** and **Class 4** laser shall be used in a controlled area with restricted access for unauthorized personnel. The controlled laser areas must be posted with appropriate warning signs.

- Each user of a Class **3B** or **Class 4** laser must wear protective equipment (e.g., eye wear and clothing) as appropriate.

- The LSO will perform periodic audits in order to assess the efficiency of the laser safety program. Any required corrective action resulting from the audit will be communicated to the RLU in a timely manner.

5.2 Engineering Controls

Lasers and laser systems are classified according to their capacity to produce ocular or skin injury. The ANSI standard describes specific controls that are recommended or required for each laser classification. Engineering controls such as fail-safe interlocks are considered to be the first line of defense and are preferable to the protection provided by administrative controls and personal protective equipment.

5.3 Beam Control

Laser beam paths and any potentially hazardous reflections such as from a non-coherent source should be enclosed, if possible. If the enclosure material is not obviously opaque material, the RLU in conjunction with the LSO must document the optical density of the

material for the wavelength(s) of the laser being used. If enclosing the beam is not practical, other beam control measures must be used, including:

- Confine the beam path to the optical bench if possible. Do not traverse populated areas or traffic areas. If traversing traffic areas is necessary, access to the area should be restricted through the use of chains, ropes or other barriers with appropriate warning signs (see Appendix E).

- All windows leaving the laser controlled area must be covered with non-reflective or diffuse reflective material.

- Material used as a barrier for **Class 4** lasers must be fire retardant.

- Turn the optical radiation off or utilize beam shutters or caps when transmission is not required.

- Terminate the beam at the end of its useful path. Beam stops should be secured with strong mechanical mounts to avoid the possibility of beam blocks moving and exposing individuals to high intensity beams.

- Whenever possible and practical, locate the beam path such that it is not at or near eye level for someone standing or sitting. **NEVER USE PERSONAL PROTECTIVE EQUIPMENT TO INTENTIONALLY VIEW THE DIRECT BEAM OF A CONTROLLED SOURCE**.

- Orient the beam so that it is not directed toward any doors.

- Orient the beam so that, as far as is possible, it is not directed upward at any time during alignment or operation. If not practical, the SOP should incorporate cautions, and appropriate protective eyewear must be worn**.**

- Create an entryway barrier using appropriate curtains, screens, etc. to block or sufficiently attenuate a beam to below the MPE at the entry. The use of door interlocks to interrupt the electrical circuit to the system is encouraged for high powered systems such as **Class 4** lasers.

- The LSO may apply alternate engineering or administrative controls to obtain equivalent optical radiation safety protection when certain engineering controls are inappropriate or impractical. This substitution will be based on the hazard evaluation.

5.4 Laser Controlled Areas (LCA)

Class 3B and **Class 4** lasers shall be operated in a designated LCA. The purpose of an LCA is to confine laser hazards to well-defined spaces that are used by the RLU and approved by the LSO for the purpose of protection from laser or optical radiation. This area must encompass at least that area in which the potential radiation exposure is greater

than the Maximum Permissible Exposure (MPE) for that laser or laser system. All personnel authorized to enter a **Class 3B**, or **Class 4** laser controlled area must be appropriately trained, and must follow all applicable administrative and operational procedures.

A laser hazard analysis, including determination of the MPE and Nominal Ocular Hazard Distance (N.O.H.D.), must be made by the LSO. If it is determined that the classification associated with the maximum level of accessible radiation is **Class 3B**, or **4**, a LCA, or Nominal Hazard Zone (NHZ) is established and control measures instituted. Control measures are only required within the NHZ. This area or zone must be visibly marked or delineated. The LSO may declare the laser use area as the NHZ in lieu of calculating all possible NHZ distances.

5.4.1 Class 3B LCA

- Must be controlled to permit laser systems to be operated only by qualified and authorized personnel.
- Must be under the supervision of an individual knowledgeable in laser safety.
- Must be posted with the appropriate warning sign(s). Refer to **Section 7** for posting requirements.
- All area or entryway safety controls must be designed to allow rapid egress by personnel and admittance to the laser controlled area under emergency conditions.
- Must, so far as is possible and practical, have the laser secured such that the beam path is not at eye level of any person in a standing or seated position.
- Must have only diffusely reflecting materials in or near the beam path where possible.
- Must have any potentially hazardous beam terminated in a beam stop of an appropriate material.
- Must have all windows, doorways, open portals, etc. either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the applicable ocular MPE.
- Must have appropriate personal protective equipment readily available (i.e., eye protection).
- Require storage or disabling (for example, removal of the key) of the laser or laser system when not in use to prevent unauthorized use.

5.4.2 Class 4 LCA

Class 4 LCA's must incorporate all Class 3B control measures, plus the following:

- Personnel who enter a **Class 4** LCA during laser operation shall be adequately trained, provided with appropriate protective equipment, and follow all applicable administrative and procedural controls.

- For emergency conditions there should be a clearly marked "Emergency Stop" (remote controlled connector or equivalent device) available for deactivating the laser or reducing the output to the appropriate MPE levels. In many cases this will be the On/Off switch on the console. If so, SOPs must include this statement. Emergency procedures shall address the need for such a shutdown, and provide appropriate directions.

- Control area interlocks or alternate controls to preclude the entry of unprotected personnel while Class 4 laser radiation is present in the LCA. The interlock system may be designed to preclude entry while the laser is operating or to terminate laser operation when the door is opened without deliberate overriding of the interlock by a trained laser user,

OR

(a) blocking barrier, screen, curtains, etc. must be used to block, screen, or attenuate the laser radiation levels so that the MPE is not exceeded at the entry point;

(b) at the entryway there must be a visible or audible signal indicating that the laser is energized and operating at Class 4 levels. A lighted laser warning sign or flashing light (visible through protective eyewear) is acceptable entryway warning light alternatives;

(c) personnel trained on entryway procedures and adequate personal protective equipment provided upon entry.

Note: Documentation of these control measures and training is recommended.

5.5 Administrative and Procedural Controls

Administrative and procedural controls are methods or instructions that specify rules, work practices, or both, which implement or supplement engineering controls. Necessary administrative and procedural controls for **Class 3B** and **4** laser and laser systems include, but are not limited to:

- SOPs– written laser specific SOPs should be developed for **Class 3B** lasers and laser systems. Written SOPs are required for **Class 4** lasers and must include procedures for operation, maintenance, and other relevant safety considerations.

- Authorized Personnel – RLU/LSO must identify authorized personnel and ensure that those personnel are the only ones that operate, maintain, or service a **Class 3B** or **4** laser or laser system. See Section 8 for training requirements.

- Alignment Procedures – ensure SOPs specify alignment procedures. See **Appendix F** for alignment guidelines.

- Use minimum laser radiation required for the application. If necessary, the LSO may require the reduction of levels of accessible power or radiant energy during the operation or maintenance of a **Class 3B** or **Class 4** laser system.

6.0 PROTECTIVE EQUIPMENT

6.1 Personal Protective Equipment

Personal protective equipment may have serious limitations and must be used only in conjunction with engineering and administrative controls, when working with **Class 3B** and **Class 4** lasers or laser systems.

6.1.1 Eye Protection

Eye protection suitable to the laser must be provided and appropriately worn within the LCA if there is a potential for exceeding the MPE limit if the beam is viewed. Laser protective eyewear is usually not required for **Class 2** through **Class 3R** lasers or laser systems, except in conditions where intentional long-term (>0.25 seconds) direct viewing is required. Protective eyewear may include goggles, face shields, spectacles or prescription eyewear using special filter materials or reflective coatings. Exceptions may be approved in the written SOPs if the eyewear produces a greater hazard than when the eye protection is not worn. Eyewear must be specifically selected to withstand either direct or diffusely scattered beams and shall meet all provisions of ANSI Z87.1-1989. (4.6.2.3) Refer to **Appendix D** for Eyewear Selection Chart. No single type of eyewear will provide protection against all wavelengths of laser radiation; therefore, eye protection should:

- Provide enough visibility to move about safely.

- Be able to withstand the maximum power of laser radiation likely to be encountered.

- Be able to absorb the specific wavelength of radiation that is being used.

- Be clearly labeled with wavelength they are designed for, the optical density at that wavelength, together with the maximum power rating.

- Be inspected periodically by the RLU to ensure that pitting, cracking and other damage will not jeopardize its effectiveness.

Lasers that can be tuned through a range of wavelengths present special problems. Broadband laser goggles may provide the level of protection required but they must be chosen with great care. If there is any doubt regarding the suitability of a particular type of eye protection, contact the LSO for guidance.

Laser eyewear may be used for wavelengths other than those designated by the manufacturer; provided that the optical densities (O.D.'s) and applicable wavelength(s) are permanently marked on the eyewear or O.D. information is readily available at the location of use. Determination of an O.D. not certified by the manufacturer must be documented by the RLU, and this documentation must be submitted to the LSO prior to use with the applicable alternate wavelengths. The LSO must be notified if the RLU procure new eyewear. Include information on the laser with which the eyewear will be used. Protective eyewear that is not effective must be discarded and replaced. Before eyewear is used, it must be checked for defects and that it is suitable for the wavelengths of lasers in use. The use of protective eyewear for a multi-wavelength system involves a complex calculation, which can be performed by the LSO if needed.

6.1.2 Skin Protection

Skin injuries from lasers primarily fall into two categories: thermal injury (burns) from acute exposure to high power laser beams and photochemically induced injury from chronic exposure to scattered ultraviolet laser radiation.

Thermal injuries can result from direct contact with the beam or specular reflections. These injuries (although painful) are usually not serious and are normally easy to prevent through proper beam management and hazard awareness.

Photochemical injury may occur over time from ultraviolet exposure to the direct beam, specular reflections, or even diffuse reflections. The effect can be similar to a minor or severe sunburn, and prolonged exposure may promote the formation of skin cancer. Proper protective eyewear and clothing may be necessary to control UV skin and eye exposure.

Skin protection can best be achieved through engineering controls. If potential skin damaging exposures exist, skin covers and or "sun screen" creams are recommended. Skin protection is particularly important when using UV sources. UV light easily scatters in laboratory settings and is not normally sensed by the human body at levels above the MPE, which can potentially cause erythema. The use of laboratory coats and UV protective creams should be considered. Minimize exposure to UV radiation by using beam shields and clothing (opaque gloves, tightly woven fabrics, laboratory jacket or coat) which attenuate the radiation to levels below the MPE for specific UV wavelengths. Consider flame-retardant materials for **Class 4** lasers. Infrared radiation is normally sensed by pain receptors within a few seconds and causes a reflex reaction to remove the exposed skin from the beam. Consult the LSO for more information.

6.1.3 Airway Protection

Airway injuries primarily occur due to the laser plume. Typically, it is an invisible cloud of suspended material with carcinogenic, toxic, or noxious airborne contaminates. Airway protection can be achieved through engineering and physical controls. In addition to local exhaust ventilation, high-filtration respirators are recommended if required or desired. Respiratory protection may be used to control brief exposures, or as an interim

control measure until other administrative or engineering controls are implemented. Consult the LSO and/or UNLV RMS.

Note: It is highly recommended that mask filtering (a minimum of 0.1 micron) be used when lasers are used on a living, biologic site.

6.2 Facility Window Protection

Exterior or interior windows that are located within the NHZ of a **Class 3B** or **Class 4** laser, or laser system, must be provided with appropriate absorbing filter, scattering filter, blocking barrier or screen to reduce any transmitted laser radiation to levels below the applicable MPE level. Important factors for selection include: ability to withstand direct and diffusely scattered beams, flammability, and decomposition products of the window material.

6.3 Laser Protective Barriers and Curtains

A blocking barrier, screen or curtain which can block or filter the laser beam at the entryway should be used inside the LCA to prevent **Class 3B** or **Class 4** laser light from exiting the area at levels above the applicable MPE level. Important factors for selection include: ability to withstand direct and diffusely scattered beams, flammability, and decomposition products of the protective barrier or curtain.

Note: Such barrier(s) must include the company and test results/certified protection level (e.g. Max Irradiance Level, Max Exposure Time, certified by laservision).

7.0 WARNING SIGNS AND EQUIPMENT LABELS

ANSI/IEC approved signs and labels are provided by the LSO and must be conspicuously displayed in locations where they best serve to warn onlookers. Personnel who do not read/understand the English language and who may need to enter areas where lasers are used must be provided appropriate instructions as to the meaning of warning signs and labels. The RLU is responsible for identifying and training such personnel.

7.1 Warning Signs

Laser controlled areas must be posted with the appropriate warning signs at the entryway(s) and if necessary, within the LCA. Refer to **Appendix E** for warning signs design.

- **Danger:** The signal word "**Danger**" indicates that death or serious injury will occur if necessary control measures are not implemented to mitigate the hazards with the laser controlled area. This signal word shall be **restricted to those Class 4** lasers with high (e.g. multi-kilowatt) output power or pulse energies with exposed beams.

- **Warning:** The signal word "**Warning**" shall be used on laser area warning signs associated with lasers and laser systems whose output exceeds the applicable MPE for irradiance, including **Class 3R**, **Class 3B** and most **Class 4** lasers.

- **Caution:** Must be used with all signs and labels associated with **Class 2** lasers and laser systems, and all **Class 2M** lasers and laser systems that do not exceed the appropriate MPE for irradiance.

- **Notice:** "**Notice**" is the preferred signal word to address practices not related to personal injury. The safety alert symbol shall not be used with this signal word. The signal word shall not be associated directly with a hazard or hazardous situation and shall not be used in place of "DANGER", "WARNING", or "CAUTION".

7.2 Equipment Label

All lasers or laser systems (except Class 1) must have appropriate warning labels affixed to a conspicuous place on both the housing and the control panel (if separated by more than 2 meters).

Class 2 lasers and laser systems, "Laser Radiation – Do Not Stare into Beam".

Class 3R lasers and laser systems (accessible irradiance does not exceed MPE based upon 0.25 second exposure for wavelengths between 0.4 and 0.7 um), "Laser Radiation – Do Not Stare into Beam or View Directly with Optical Instruments".

All other Class 3R lasers or laser systems, "Laser Radiation – Avoid Direct Eye. Exposure"

Class 3B lasers or laser systems, "Laser Radiation – Avoid Direct Exposure to Beam".

Class 4 lasers or laser systems, "Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation".

7.3 Labeling of Protective Equipment

7.3.1 Labeling of Protective Eyewear

All eyewear must be clearly labeled with the optical density and wavelength. Color-coding or other distinctive identification is recommended in multi-laser environments.

7.3.2 Labeling of Laser Protective Windows and Collecting Optic Filters

All laser protective windows must be labeled with the optical density and wavelength(s) for which protection is afforded, and should be labeled with the threshold limit and exposure time for which the limit applies, and the conditions under which protection if afforded.

7.3.3 Labeling of Laser Protective Barriers

All laser protective barriers must be labeled with the barrier threshold limit and exposure time for which the limit applies, and beam exposure conditions under which protection is afforded. Contact the LSO for assistance.

8.0 NON-BEAM HAZARD

While beam hazards are the most prominent laser hazards, many non-beam hazards may be present in a controlled optical device laboratory. It is the responsibility of the approved user to take proper precautions to prevent injury due to these collateral hazards. The UNLV RMS is available to assist with evaluation of these hazards, which may include:

8.1 Electrical Hazards

The most lethal non-beam hazard associated with lasers is the high voltage electrical system required to power lasers. Some lasers use high-voltage power supplies, large capacitors, or capacitor banks that present a lethal shock hazard. Additional hazards of electrical equipment include resistive heating and ignition source. The following is a list of recommended electrical safety practices:

- **Class 3B** and **4** lasers should have a separate circuit and local cut-off switch (breaker) for the circuit.
- Label and post electrical high voltage hazards and switches. Clearly identify the main switches to cut-off power.
- Do not wear rings, watches or other metallic apparel when working with electrical equipment.
- When working with high voltages, regard all floors as conductive and grounded.
- Do not handle electrical equipment when hands or feet are wet or when standing on a wet floor.
- Be familiar with electrocution rescue procedures and emergency first aid.
- Check the condition of electrical insulation and ensure that electrical terminals are covered; repair or replace damaged equipment.
- Ensure good equipment grounding (i.e., chassis/frame resistance to ground limited to a few ohms).
- Follow good wiring practices [e.g. use GFCI outlets, no uncovered wires on the floor, (**cover all wires on the floor with a channel or ramp to prevent stepping on the wire)**; watch for and avoid overloaded circuits, etc.].

- Use equipment only for its intended/designed purpose.

- Prior to working on electrical equipment, de-energize the power source. Lockout and tag-out the disconnect switch.

- Have at least two persons in an area while working on high-energy power systems.

- Check that each capacitor is discharged and grounded prior to working in the area of the capacitors. A shorting wire connected to ground through a current limiting resistor should be used to discharge all high voltage capacitors. High voltage capacitors, once discharged, should be shorted when not in use and outside of their manufactured housing. Shorts are to be removed when reassembling the unit.

- Use shock preventing shields, power supply enclosures, and shielded leads in all experimental or temporary high-voltage circuits.

- Keep cooling water connections away from main power and high voltage outlets and contacts. Use double hose clamps on cooling water hoses. Inspect cooling water hoses and connections and power cables and connectors periodically as part of a regular equipment inspection. Check with the LSO on the proper installation of cooling water lines.

8.2 Laser-Generated Air Contaminants (LGAC)

Air contaminants may be generated when **Class 3B** and **Class 4** laser beams interact with matter. When target irradiance reaches a threshold of about 10^7 W/cm^2, target materials including plastics, composites, metals, and biologic tissues may liberate toxic and noxious airborne contaminants, as well as living organisms, such as viruses. Generally, the RLU must ensure that any laser operation that may potentially create airborne toxins, noxious gases, and/or large quantities of non-toxic oxygen displacing gases has adequate local exhaust ventilation in place and included in the SOP; respiratory protection is not an acceptable alternative to local exhaust ventilation. If, in addition to local exhaust ventilation, respiratory protection is required or desired, consult the LSO and/or UNLV RMS. UV lasers and intense UV sources operating in the atmosphere may produce dangerous levels of ozone. Appropriate ventilation is required.

8.3 Collateral and Plasma Radiation

Radiation other than that associated with the primary laser beam is called *collateral radiation.* Examples are Ionizing Radiation (X-rays), Infrared, Ultraviolet, and Visible Radiation, Plasma Radiation, and Radio Frequency Emissions.

8.3.1 Ionizing Radiation (X-rays)

X-rays can be produced from two main sources in the laser laboratories: Electric-discharge lasers and high-voltage vacuum tubes of laser power supplies. Any power supplies that require more than 15 kilovolts (kV) may produce enough X-rays to cause a health hazard. Interaction between X-rays and human tissue may cause an increasing probability of cancer.

8.3.2 Infrared (IR), Ultraviolet (UV), and Visible Radiation

Laser discharge tubes and pump lamps may generate sufficient IR, UV, and visible radiation to pose an eye and skin hazard. The levels of produced exposure may exceed the MPE limit and thus cause skin and eye damage. To address this issue, maintain the integrity of the laser housing and do not operate any laser with the housing removed.

8.3.3 Plasma Radiation

Interactions between very high power (~10^{12} W/cm²) laser beams and target materials may produce *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 RLU must ensure adequate control measures are in place and addressed in the SOP for such operations.

8.3.4 Radiofrequencies (RF) Emission

Q switches and plasma tubes are RF excited components. Unshielded components may generate radio frequency fields that exceed federal guidelines.

8.4 Fire Hazards

Class 4 laser beams represent a fire hazard, and under some situations, it is possible that **Class 3B** lasers can initiate fires. Depending on the construction material, beam enclosures, barriers, stops and wiring are all potentially flammable if exposed to high beam irradiance for more than a few seconds. Use flame retardant materials wherever applicable with all laser applications. Laser Users should be aware that opaque laser barriers, (e.g. curtains), can be designed to offer a range of protection; however, they normally cannot withstand high irradiance levels for more than a few seconds without some damage, (e.g., production of smoke, open fire, or penetration). Operators of **Class 4** lasers should also be aware of the ability of unprotected wire insulation and plastic tubing to catch on fire from intense reflected or scattered beams, particularly from lasers operating at invisible wavelengths.

8.5 Explosion Hazards

High-pressure arc lamps, filament lamps, and capacitors may explode if they fail during operation. Keep these components enclosed in the laser housing, which will withstand the maximum explosive forces that may be produced. Laser targets and some optical

components also may shatter if heat cannot be dissipated quickly enough. Ensure adequate mechanical shielding when exposing brittle materials to high intensity lasers.

8.6 Chemical Hazards

The SOP should contain references for the safe handling of hazardous chemicals and compressed gases.

8.6.1 Laser Dyes

Dyes used as the optically active medium in some lasers are often toxic and/or carcinogenic chemicals dissolved in flammable solvents. This creates the potential for personnel exposures above permissible limits, fires, and chemical spills. For each dye used, the RLU must have the MSDS available for staff review and in general ensure compliance with applicable UNLV RMS policy governing hazardous chemical use and disposal.

Various gases may be exhausted by lasers or produced by irradiated targets. Proper ventilation is required to reduce exposure levels of the gas products below acceptable limits.

8.6.2 Compressed Gases

Compressed gases used in lasers also present potential health and safety hazards. Problems may arise when working with unsecured cylinders, cylinders of hazardous materials not maintained in ventilated enclosures, and gases of different categories (toxins, corrosives, flammables and oxidizers) are stored together.

8.6.3 Cryogenic fluids

Cryogenic fluids are used in the cooling systems of certain lasers. As these materials evaporate, they replace the oxygen in the air; thus, adequate ventilation must be ensured. Cryogenic fluids are potentially explosive when ice collects in valves or connectors that are not specifically designed for use with cryogenic fluids. Condensation of oxygen in liquid nitrogen presents a serious explosion hazard if the liquid oxygen comes in contact with any organic materials.

8.6.4 Liquid Nitrogen

Although the quantities of liquid nitrogen used are normally small, protective clothing and face shields should be used to prevent freeze burns to the skin and eyes.

8.7 Noise, Work Space and Ergonomics

A good "rule of thumb" for determining if your work area or activity requires hearing protection is as follows. If you have difficulty hearing or understanding a "normal" tone of voice at a distance of about three feet, noise levels are probably exceeding safe levels

and you should be using hearing protection. Please contact the UNLV RMS for an evaluation.

Limited workspace can be a problem especially while working near or around mechanical or high voltage equipment. In all cases there must be sufficient room for personnel to turn around and maneuver freely.

Consider ergonomic principles in laser system designs, such as positioning of the laser system and area illumination.

9.0 TRAINING

All employees who use **Class 3B** or **Class 4** lasers must complete the appropriate laser Safety course, as well as other appropriate courses. Training shall enable employees to acquire the understanding, knowledge, and skills necessary to perform assigned duties relevant to working around and/or with controlled optical devices.

9.1 Initial Training. Initial training shall be provided prior to assignment to working in a controlled area containing hazardous optical systems. The initial training may be conducted by challenge exam, in a classroom setting, online, or by faculty or staff having the requisite knowledge and experience. Training shall be documented with RMS.

9.2 Re-training. Re-training shall be provided whenever:

- There is a change or modification in laser system, operations, procedures or hazards.
- There is reason to believe that there are inadequacies in the employees' knowledge to safely use hazardous optical devices.

9.3 Laser-specific Training. Laser users are responsible for knowing the safety requirements that apply to their specific laser or laser system and for knowing the contents of the applicable SOP. The laser-specific training normally takes place in a classroom setting, face to face with the LSO or the RLU, or on-line based on LSO approval.

9.4 Update Training. Laser users must annually retake the applicable laser safety course. The update training is normally conducted on-line, but classroom setting training is also available.

9.5 Visitors. Guests of UNLV requesting to use or observe **Class 3B or 4** lasers without RLU or designated ILU supervision must contact the LSO regarding the training requirement for non-UNLV personnel. New employees and guests may use lasers only under the **direct supervision of a RLU until training is completed**. Visitors wishing to observe **Class 3B** or **4** lasers **must be under direct supervision of the RLU or designated ILU, and must be instructed in the hazards of the laboratory and**

provided with appropriate personal protective equipment prior to entering the laboratory.

9.6 Elements of Training:

- UNLV Laser Safety Program and regulations.
- Duties of LSO, RLU, and ILU.
- Description of the Laser, Laser System, and LCA.
- Review of Operating Procedures and Emergency Procedures.
- Review of the SOP for Use, Set-up and Alignment, if applicable.
- Selection and use of Personal Protective Equipment, if required.
- Identification and proper use of Engineering Controls.
- Identification of Administrative Controls, including warning signs and labels.
- Identification of Non-Beam Safety Hazards associated with the system or multiple laser systems used in a LCA.

10.0 MEDICAL SURVEILLANCE

The requirement for eye examinations for laser users has changed in recent years. Currently, routine pre-placement examinations are NOT required. Examinations are now required only at the discretion of the LSO. Such discretion may be based on an actual or suspected overexposure to laser or optical radiation. Following any suspected laser injury, employees must report to the RLU and LSO if they believe that they have been injured.

11.0 EMERGENCY PROCEDURES

Laser users must report all laser accidents on site, no matter how minimal, to the RLU responsible for the laser system involved. The RLU and the worker must report any accidents causing injury or property damage to the LSO and Workers' Compensation at the RMS. If immediate assistance is required, contact the LSO and UNLV Police Services, indicate to the Police Services that a laser accident has occurred, and direct them to notify the LSO to respond to the situation. A Laser Incident Report Form shall be filled out and submitted to RLU/LSO promptly.

Laser Safety Officer (LSO)	(working hours)	**702-895-4226**	main line
	(working hours)	**702-895-4419**	office

(after working hours, weekends, and holidays) **702-340-4419** cell phone

Police Services **911**

The accident must be reported by the RLU to RMS within seven (7) calendar days to maintain compliance with Worker's Compensation rules. The LSO will perform an investigation of the incident and present those results to the RLU, the RMS executive staff, and members of the LSAC.

12.0 RECORD KEEPING

The RLU and LSO are responsible for maintaining all laser safety-related records (i.e., laser safety training, SOPs, inspections/audits, incident reports) for each employee for a minimum of one year. For general purposes, it is recommended that records be maintained as long as required by regulations governing control of the facility. Documents and records pertinent to this section shall be retained per the following table:

Records	Responsible Department	Retention
Written Procedure	RMS & Affected Departments	Latest Revision
Training Course Materials	RMS	Latest Revision
Training Records	RMS	Latest Revision
Registered User	RMS	Latest Revision
Registered lasers	RMS	Latest Revision

Appendix A: Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
cd	candela
cm	centimeter
CW	continuous wave
GFCI	ground fault circuit interrupter
HID	high-intensity discharge
ILU	Individual Laser User
IR	infrared radiation
kV	kilovolt
LCA	Laser Controlled Areas
LGAC	Laser-Generated Air Contaminants
LSAC	Laser Safety Advisory Committee
LSO	Laser Safety Officer
µW	microwatt
mW	milliwatt
MPE	maximum permissible exposure
MSDS	Material Safety Data Sheet
NHZ	nominal hazard zone
N.O.H.D.	Nominal Ocular Hazard Distance
O.D.	optical density
RF	radiofrequency
RLU	Registered Laser User
RMS	Risk Management and Safety
SG1	Service Group 1
SOP	standard operating procedure
TLV	Threshold Limit Value
UNLV	University of Nevada, Las Vegas
UV	ultraviolet
W	watt

Appendix B: Definitions

B.1 **Beam.** A collection of rays that may be parallel, convergent, or divergent.

B.2 **Continuous wave.** The output of a laser which is operated in a continuous rather than a pulsed mode. In this document, a laser operating with a continuous output for a period greater than 0.25 s is regarded as a CW laser.

B.3 **Closed Installation.** Any location where lasers are used which will be closed to unprotected personnel during laser operation.

B.4 **Coherent.** A beam of electromagnetic radiation whose photons all have the same optical properties (wavelength, phase, and direction).

B.5 **Controlled Area (Controlled Laser Area).** The area where the occupancy and activity of those personnel within is subject to control and supervision for the purpose of protection from laser radiation hazards.

B.6 **Diffuse Reflection**. Takes place when different parts of a beam incident on a surface are reflected over a wide range of angles in accordance with Lambert's Law. The intensity will fall off as the inverse of the square of the distance away from the surface and also obey a Cosine Law of reflection.

B.7 **Embedded Laser.** A laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the system's lower classification is appropriate to the engineering features limiting accessible emission.

B.8 **Emission**. Act of giving off radiant energy by an atom or molecule.

B.9 **Emission Delay**. Time between warning system activation and activation of the laser or laser system. The delay must be sufficient to allow appropriate action to be taken to avoid exposure to laser radiation. Required for Class 4 laser or laser systems.

B.10 **Enclosed Device.** Any laser or laser system located within an enclosure which does not permit hazardous optical radiation emission from the enclosure. The laser inside is termed an "embedded laser."

B.11 **Excimer ("Excited Dimer").** A gas mixture used as the active medium in a family of lasers emitting ultraviolet light.

B.12 **Fail-safe Interlock.** An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

B.13 **Infrared Radiation.** Invisible electromagnetic radiation with wavelengths which lie within the range of 0.70 to 1000 µm. These wavelengths are often broken up into regions: IR-A (0.7-1.4 µm), IR-B (1.4-3.0 µm) and IR-C (3.0-1000 µm).

B.14 **Interlocks.** Engineering control designed to prevent access to laser radiation above the applicable maximum permissible exposure. The interlock may, for example, be electrically or mechanically interface to a shutter that interrupts the beam when the protective housing is opened or removed. Interlocks on protective

housings that enclose **Class 3B**or **4** lasers or laser systems are required. Remote interlocks for rooms, entryways, or areas are recommended for Class 3Blasers or laser systems and required for **Class 4** lasers or laser systems.

B.15 **Intrabeam Viewing.** The viewing condition whereby the eye is exposed to all or part of a direct laser beam or a specular reflection.

B.16 **Irradiance (E).** Radiant flux (radiant power) per unit area incident upon a given surface. Units: Watts per square centimeter. (Sometimes referred to as power density).

B.17 **Key Control.** Single master switch operated by a key, or by a coded access required for beam and/or system activation. Required for **Class 4** lasers or laser systems and recommended for **Class 3B** lasers or laser systems.

B.18 **Laser.** A device that produces radiant energy pre-dominantly by stimulated emission. Laser radiation may be highly coherent temporally, or spatially, or both. An acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

B.19 **Laser barrier.** A device used to block or attenuate incident direct or diffuse laser radiation. Laser barriers are frequently used during times of service to the laser system when it is desirable to establish a boundary for a temporary (or permanent) laser controlled area.

B.20 **Laser Device.** Either a laser or a laser system.

B.21 **Laser Safety Officer.** One who has authority to monitor and enforce the control of laser hazards and the knowledge to evaluate and control laser hazards.

B.22 **Laser or Optical System.** An assembly of electrical, mechanical and optical components which includes a laser or optical source of non-coherent radiation.

B.23 **Light.** The range of electromagnetic radiation frequencies detected by the eye, or the wavelength range from about 400 to 760 nm. The term is sometimes used loosely to include radiation beyond visible limits.

B.24 **Maintenance.** Performance of those adjustments or procedures specified in user information provided by the manufacturer with the laser or laser system, which are to be performed by the user to ensure the intended performance of the product. It does not include operation or service.

B.25 **Maximum Permissible Exposure.** The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin.

B.26 **Must.** The word “must” is to be understood as mandatory.

B.27 **Nominal Hazard Zone.** The nominal hazard zone describes the space within which the level of the direct, reflected or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

B.28 **Non-beam hazard.** A class of hazards that result from factors other than direct human exposure to a laser beam.

B.29 **Operation.** The performance of the laser or laser system over the full range of its intended functions (normal operation). It does not include *maintenance* or *service* as defined in this section

B.30 **Protective housing.** An enclosure surrounding the laser or laser system that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing may enclose associated optics and a workstation, and limits access to other associated radiant energy emissions and to electrical hazards associated with components and terminals.

B.31 **Pulsed Laser.** A laser which delivers its energy in the form of a single pulse or a train of pulses.

B.32 **Radiant Energy (Q).** Energy in the form of electromagnetic waves usually expressed in units of Joules (watt-seconds).

B.33 **Radiant Exposure (H).** The total energy per unit area incident upon a given surface. It is used to express exposure to pulsed laser radiation in units of J/cm^2.

B.34 **Reflection.** The return of radiant energy (incident light) by a surface, with no change in wavelength.

B.35 **Refraction.** The bending of a beam of light in transmission through an interface between two dissimilar media or in a medium whose refractive index is a continuous function of position (graded index medium).

B.36 **Repetitive pulse Laser.** A laser with multiple pulses of radiant energy occurring in a sequence.

B.37 **Retinal hazard region.** Optical radiation with wavelengths between 0.4 and 1.4 um, where the principal hazard is usually to the retina

B.38 **Secured Enclosure.** An enclosure to which casual access is impeded by an appropriate means (e.g., door secured by lock, magnetically or electrically operated latch, or by screws).

B.39 **Service.** Performance of adjustments, repair or procedures on a non-routine basis, required to return the equipment to its intended state.

B.40 **Shall.** The word “shall” is to be understood as mandatory.

B.41 **Should.** The word “should” is to be understood as advisory.

B.42 **Source.** The term source means either laser or laser-illuminated reflecting surface, i.e., source of light.

B.43 **Spectator.** An individual who wishes to observe or watch a laser or laser system in operation, and who may lack the appropriate laser safety training.

B.44 **Specular reflection.** A mirror-like reflection.

B.45 **Standard operating procedure.** Formal written description of the safety and administrative procedures to be followed in performing a specific task.

B.46 **Threshold Limit Value,** Guidelines (**not** standards) prepared by the American Conference of Governmental Industrial Hygienists (ACGIH) to assist industrial hygienists in making decisions regarding safe levels of exposure to various hazards found in the workplace. A TLV® reflects the level of exposure that the typical worker can experience without an unreasonable risk of disease or injury.

B.47 **Ultraviolet Radiation.** Electromagnetic radiation with wavelengths between soft X-rays and visible violet light, often broken down into UV-A (315-400 nm), UV-B (280-315 nm), and UV-C (100-280 nm).

B.48 **Uncontrolled area.** An area where the occupancy and activity of those within is not subject to control and supervision for the purpose of protection from radiation hazards.

B.49 **Visible Radiation (light).** Electromagnetic radiation which can be detected by the human eye. It is commonly used to describe wavelengths in the range between 400 nm and 700-780 nm.

B.50 **Wavelength.** The distance between consecutive crests of a wave. Common units of measurement are the micrometer (micron), the nanometer, and (earlier) the Angstrom unit.

Appendix C: Common Types of Lasers

LASER	WAVELENGTH (µm)	TYPE	MODE
Argon (Ar)	0.488, 0.514, et. **Also UV**	gas	CW, P
Carbon Dioxide (CO_2)	9.6, 10.6	gas	CW, P
Copper Vapor (Cu)	0.510, 0.578	gas	CW, P
Gallium Arsenide (GaAs)	0.820 - 0.95	semiconductor	CW, P
Helium Cadmium (HeCd)	0.325, 0.441	gas	CW
Helium Neon (HeNe)	0.543, 0.594, 0.612, 0.633, 1.152, 3.390	gas	CW
Mercury Vapor (Hg)	0.48, 0.615, 1.530, 1.813	gas	CW
Neodymium YAG (Nd:YAG)	0.266, 0.532, 1.064, 1.33	solid	CW, P
Nitrogen (N_2)	0.337	gas	P
Rhodamine 6G	0.570 - 0.650	liquid (dye)	CW, P
Ruby	0.694	solid	P
Ti :Sapphire	0.670 - 1.070	solid	CW, P
Water Vapor (H_2O)	27.974, 33.033	gas	CW
Xenon Chloride	0.308	gas (eximer)	CW, P
Xenon Fluoride	0.351	gas (eximer)	CW, P
Nd:YLF	1.047	Solid	P
Kr	0.476 to 0.647	Gas	CW

Appendix D: Eyewear Selection Chart

Simplified Method for Selecting laser Eye Protection for Intrabeam Viewing for Wavelengths between 400 and 1400nm

Q-Switched Lasers (1 ns to 0.1 ms)		Non-Q-Switched Lasers (0.4 ms to 10 ms)		Continuous Lasers Momentary (0.25 s to 10 s)		Continuous Lasers Long-Term Staring Greater than 3 hours		Attenuation	
Maximum Output Energy (J)	Maximum Beam Radiant Exposure ($J \cdot cm^{-2}$)	Maximum Laser Output Energy (J)	Maximum Beam Radiant Exposure ($J \cdot cm^{-2}$)	Maximum Power Output (W)	Maximum Beam Irradiance ($W \cdot cm^{-2}$)	Maximum Power Output (W)	Maximum Beam Irradiance ($W \cdot cm^{-2}$)	Attenuation Factor	O.D.
10	20	100	200	NR	NR	NR	NR	1×10^{-8}	8
1.0	2	10	20	NR	NR	NR	NR	1×10^{-7}	7
10^{-1}	2×10^{-1}	1.0	2	NR	NR	1.0	2	1×10^{-6}	6
10^{-2}	2×10^{-2}	10^{-1}	2×10^{-1}	NR	NR	10^{-1}	2×10^{-1}	1×10^{-5}	5
10^{-3}	2×10^{-3}	10^{-2}	2×10^{-2}	10	20	10^{-2}	2×10^{-2}	1×10^{-4}	4
10^{-4}	2×10^{-4}	10^{-3}	2×10^{-3}	1.0	2	10^{-3}	2×10^{-3}	1×10^{-3}	3
10^{-5}	2×10^{-5}	10^{-4}	2×10^{-4}	10^{-1}	2×10^{-1}	10^{-4}	2×10^{-4}	1×10^{-2}	2
10^{-6}	2×10^{-6}	10^{-5}	2×10^{-5}	10^{-2}	2×10^{-2}	10^{-5}	2×10^{-5}	10	1

NR = Not Recommended

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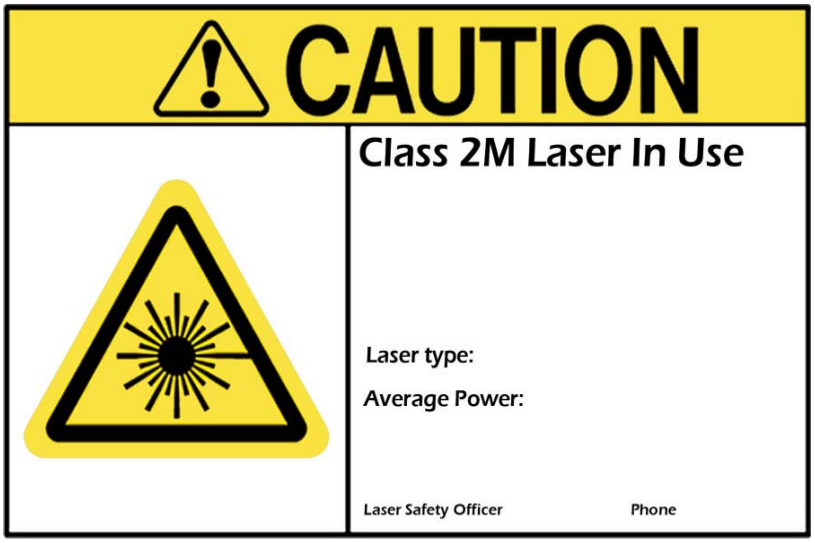
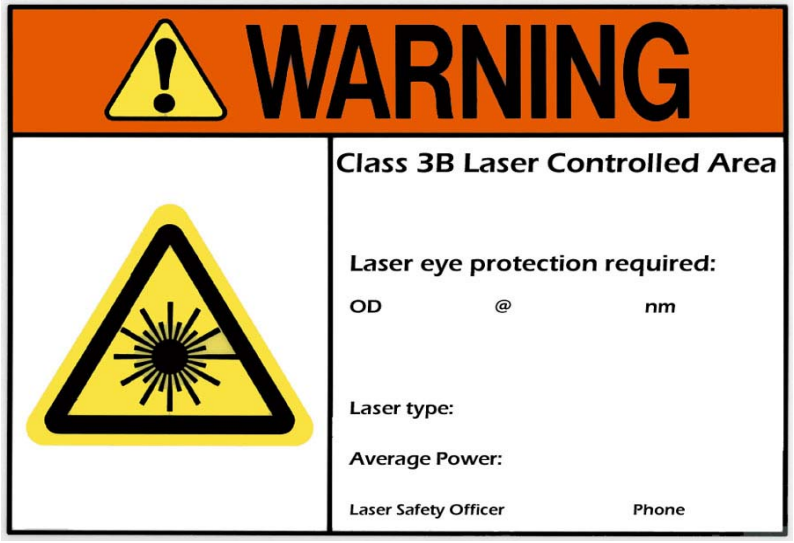
Appendix E: Laser and Optical Source Warning Signs

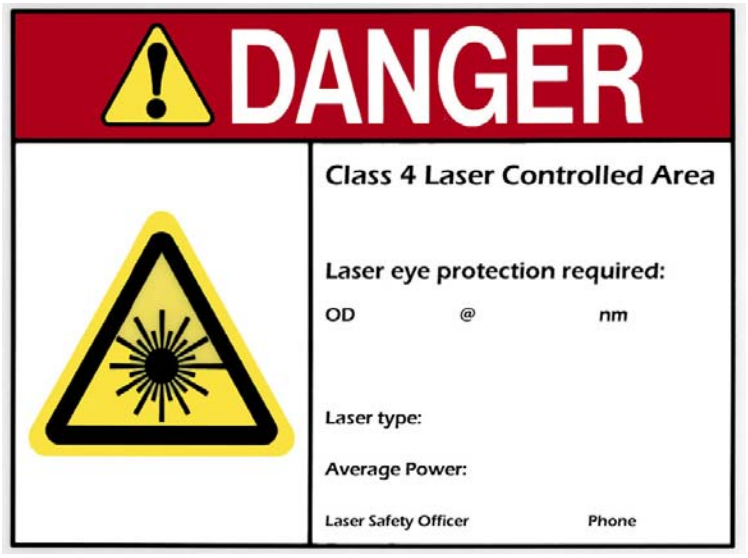
E.1 Class 2 and 2M Laser Caution Warning Sign



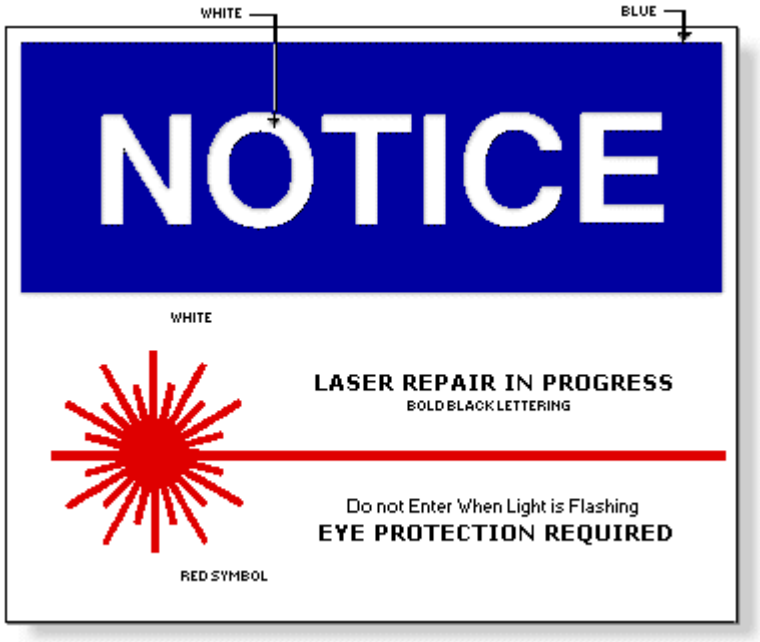
E.2 Class 3B/4 Laser Warning Warning Sign



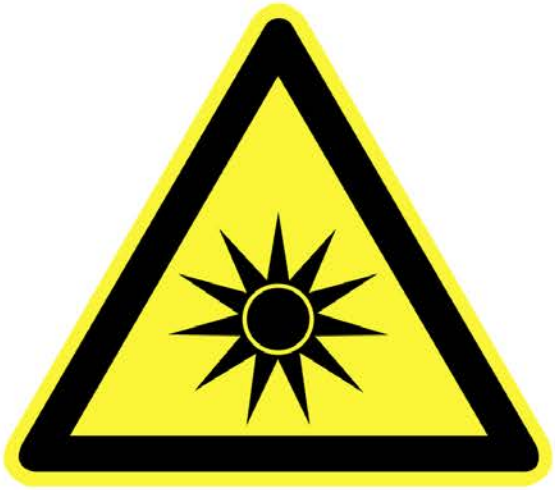
E.3 Class 4 Laser Danger Warning Sign



E.4 Laser Repair Warning Sign



E.5 Optical Source Warning Sign



Appendix F: Guidelines and Operation Procedures

F.1 Laser Laboratory General Rules

1. Horseplay and unprofessional conduct in the laboratory will not be tolerated.
2. All jewelry (earrings, necklaces, bracelets, etc.) must be removed.
3. Long hair must be tied back or confined by some sort of hat or hair net.
4. Loose clothing is not allowed unless covered by a laboratory coat with tight long sleeves.
5. Shoes must be worn in the laboratory (bare foot, flip-flops, roller blades, roller skates, etc. are not allowed).
6. Personal are restricted from the laboratory if are under the influence of alcohol or drugs.
7. Smoking, eating, or drinking is not allowed in the laboratory.
8. When lasers are operating, protective eyewear must be properly worn in the LCA. If you wear glasses, safety eyewear must completely cover the glasses, except when an exception is explicitly stated (e.g. soldering). Goggles need not be worn in the laboratory outside the LCA.
9. Never look directly in the path of the laser beam, even while wearing safety eyewear.
10. Modern lasers have built-in turn on delay circuits. NEVER look directly into the laser while the source is plugged into the electrical outlet. ALWAYS unplug the power source first before looking directly into the laser head.
11. It is not known if low frequency electric and magnetic fields are a health risk. It is strongly advised that pregnant women and people who require electronic assistance (e.g. pacemakers, hearing aids, etc.) or have any other health concerns not enter the laboratory without first consulting their physician and the laboratory supervisor and/or LSO. The supervisor and/or LSO may require a written release from the physician.
12. Know the location of:
    a. Laser Warning Light Switch
    b. Emergency Cut Off Switch
    c. Light Switches
    d. Phone
    e. PPE (Safety Glasses, Lab Coat, Laser Safety Goggles)
    f. Fire Extinguisher
    g. SOP and Laser Safety Manual

13. Unsupervised experimentation is not to be performed by students between 6 p.m. and 8 a.m. during the regular work week or on holidays or on weekends unless the RLU is on campus. This may be waived only by the LSO.
14. Unauthorized personnel are not allowed in to the laboratory without the RLU approval.
15. Do not touch equipment you are not authorized to use. Some of the equipment is very delicate and expensive. Some of the equipment does not belong to UNLV.
16. Unless otherwise directed, do NOT disturb experimental setups in the laboratory. If it was done accidentally it must be reported to the RLU.
17. Compressed flammable gases exist in the laboratory. They are properly stored and the room is properly vented. Laser exhaust (carbon monoxide; CO) is properly vented as well. Before you may use the gases, you must be properly trained in operating the gas tanks and in detecting leaks in the gas lines.
18. Follow approved SOPs for compressed gas usage and for laser operation.
19. Laser and laser sources contain high voltage sources within. You may not open or modify these without the permission of the RLU.
20. Laser beams are not to extend above the height of the laser shielding.
21. Be familiar with the posted emergency response plan. If an accident/incident occurs, the RLU and LSO must be notified promptly.
22. Maintaining of laser control area log book by RLU and ILU is strongly recommended. The logs must contain the following minimum requirements: name, date, time the lab entered and exited (details such as breaks, etc. not necessary), in what capacity the laboratory was used, details of experiment or design conducted in laboratory, and resources used.

ALWAYS BE AWARE OF YOUR SURROUNDINGS. ALWAYS BE ALERT. REMEMBER SAFETY FIRST.

F.2 Laboratory Operating Procedures for CO_2 (Carbon Dioxide) Laser, Normal Operation

1. Unauthorized personnel are to leave the room.
2. Laser operation shall be done by properly trained and authorized personnel.
3. Turn on the "LASER IN USE" warning light. Verify that the proper laser warning sign is posted. The laboratory door is to be locked for controlled access.
4. Laser operation shall not be initiated unless all precautionary measures are in place.
5. Check exhaust hose connection such that exhaust leaves room properly.
6. Check that the interlock on the door accessing the laboratory is secure if applicable.
7. Check that the interlock on the laser hood is secure if applicable.
8. Appropriately, install an absorbing background (i.e., Masonite board, welder's curtain, large surface area detectors, etc.) near the laser outputs to prevent spectral reflection.
9. Supply power to laser electronics. High voltage to the laser cavity is OFF.
    a. Plug in laser.
    b. Turn key lock to ON position.
10. Fill laser cavity with gas mixture.
    a. Adjust pressure to cavity at the mounted tanks.
    b. Adjust flow rates from external flow meters.
    c. Adjust cavity pressure at exhaust valve on laser
11. Authorized personnel without CO_2 safety goggles are required to leave control area.
12. Authorized personnel in control area instructed and required to remove all jewelry and use proper PPE.
13. High voltage to laser is turned on.
14. Laser may be triggered manually on site or by remote control.
15. Mirror or experiment adjustments may require personnel to be in the local vicinity of the laser beam. Personnel are not to place any part of body in the beam's path and are not allowed to look into the laser. [In the advent when both ports of the cavity are terminated by transparent (non-reflected, non-focusing or magnifying) windows, personnel are allowed to remove their goggles and are allowed to peer directly inside the laser cavity. Under these conditions lasing does not occur. This may be necessary to determine suitable gas mixture and cavity voltages].

16. After the experiment is completed, the high voltage power is switched OFF. Safety goggles may now be removed.
17. The keyed on/off switch is turned OFF.
18. All unauthorized personnel are now allowed to enter control area.
19. The gas is turned off at the gas regulators on the gas tank. The gas input and output ports are closed. Gas tank valves are turned closed.
20. The laser safety light is turned OFF. Laboratory doors are unlocked.

F.3 Laboratory Operating Procedures for CO_2 (Carbon Dioxide) Laser, Mirror Alignments and Maintenance

1. Unauthorized personnel are to leave the room.
2. Laser operation shall be done by properly trained and authorized personnel.
3. Turn on the "LASER IN USE" warning light. Verify that the proper laser warning sign is posted. The laboratory door is to be locked for controlled access.
4. Laser operation shall not be initiated unless all precautionary measures are in place.
5. Check exhaust hose connection such that exhaust leaves room properly.
6. Check that the interlock on the door accessing the laboratory is secure if applicable.
7. Authorized personnel remaining in the room are informed on the possible generation of electromagnetic pulses in the advent that the laser hood is removed.
8. Authorized personnel without CO_2 safety goggles are required to leave control area.
9. Authorized personnel in control area are instructed on:
    a. The high voltage dangers in the laser electronics.
    b. The dangerous conditions due to gas leaks
10. If necessary, the laser hood is removed and the hood interlocks are defeated.
11. High voltage capacitors are discharged.
12. Appropriately, install an absorbing background (i.e., Masonite board, welder's curtain, large surface area detectors, etc.) near the laser outputs to prevent spectral reflection.
13. Supply power to laser electronics. High voltage to the laser cavity is OFF.
    c. Plug in laser.
    d. Turn key lock to ON position.
14. Fill laser cavity with gas mixture.
    e. Adjust pressure to cavity at the mounted tanks.
    f. Adjust flow rates from external flow meters.
    g. Adjust cavity pressure at exhaust valve on laser
15. Authorized personnel in control area instructed and required to remove all jewelry and use proper PPE.
16. High voltage to laser is turned on.
17. Laser may be triggered manually on site or by remote control.

18. Mirror or experiment adjustments may require personnel to be in the local vicinity of the laser beam. Personnel are not to place any part of body in the beam's path and are not allowed to look into the laser. [In the advent when both ports of the cavity are terminated by transparent (non-reflected, non-focusing or magnifying) windows, personnel are allowed to remove their goggles and are allowed to peer directly inside the laser cavity. Under these conditions lasing does not occur. This may be necessary to determine suitable gas mixture and cavity voltages].
19. After the experiment is completed, the high voltage power is switched OFF. Safety goggles may now be removed.
20. The keyed on/off switch is turned OFF.
21. All unauthorized personnel are now allowed to enter control area.
22. The gas is turned off at the gas regulators on the gas tank. The gas input and output ports are closed. Gas tank valves are turned closed.
23. The laser safety light is turned OFF. Laboratory doors are unlocked.

F.4 Laboratory Operating Procedures for Turning Gas Tanks ON & OFF

1. Check that all gas tanks are properly secured to the wall.
2. Check that all hoses are properly connected and are damage and kink free.
3. Twist valve handle on the pressure regulator until membrane controlling gas flow between the input and output ports is not compressed.
4. Slowly turn gas tank valve to open.
5. Check for gas leaks at the regulator.
6. If a leak is suspected at any point of the procedure, secure gas flow immediately and proceed to locate and eliminate the leak appropriately and safely. Call RLU and/or LSO for assistance.
7. Slowly turn the regulator valve to open.
8. Check for any leaks at all hose connections.
9. Adjust regulator output pressure appropriately.
10. When completed, close regulator valve. Regulator handle should not compress the membrane controlling the gas flow in the regulator.
11. Close gas tank valves.

F.5 Laboratory Operating Procedures for Ruby Laser, Normal Operation

1. Unauthorized personnel are to leave the room.
2. Laser operation shall be done by properly trained and authorized personnel.
3. Turn on the "LASER IN USE" warning light. Verify that the proper laser warning sign is posted. The laboratory door is to be locked for controlled access.
4. Laser operation shall not be initiated unless all precautionary measures are in place.
5. Check that the interlock on the door accessing the laboratory is secure if applicable.
6. Check that the laser hoods are appropriately covering the laser beam path whenever possible and applicable.
7. Appropriately, install an absorbing background (i.e., Masonite board, welder's curtain, large surface area detectors, etc.) near the laser outputs to prevent spectral reflection.
8. Authorized personnel in control area instructed and required to remove all jewelry and use proper PPE.
9. Supply power to laser electronics. High voltage to the laser cavity is OFF.
    a. Plug in laser.
    b. Turn key lock to ON position.
10. All authorized personnel are required to stay within the radio frequency shielding room during the operation of the laser. Remote firing is required.
11. High voltage to laser is turned ON.
12. After the experiment is completed, the high voltage power is switched OFF.
13. All unauthorized personnel are now allowed to enter the control area.
14. The laser safety light is turned OFF. Laboratory doors are unlocked.

F.6 Laboratory Operating Procedures for HeNe (Helium Neon) Laser (5-10 mW), Normal Operation

1. Unauthorized personnel are to leave the room.
2. Laser operation shall be done by properly trained and authorized personnel.
3. Turn on the "LASER IN USE" warning light. Verify that the proper laser warning sign is posted. The laboratory door is to be locked for controlled access.
4. Laser operation shall not be initiated unless all precautionary measures are in place.
5. Check that the interlock on the door accessing the laboratory is secure if applicable.
6. Check that the laser hoods are appropriately covering the laser beam path whenever possible and applicable.
7. Appropriately, install an absorbing background (i.e., Masonite board, welder's curtain, large surface area detectors, etc.) near the laser outputs to prevent spectral reflection.
8. Authorized personnel in control area instructed and required to remove all jewelry and use proper PPE.
9. Authorized personnel are instructed not to look directly into the laser beam or its spectral reflection.
10. The laser head is connected to the key controlled power supply with key in the OFF position. Check that the connection is secure so to avoid high voltage hazard.
11. Power supply is plugged into the wall.
12. Key is turned ON with laser safety window closed until beam is needed.
13. After the experiment is completed the laser is turned OFF.
14. All unauthorized personnel are now allowed to enter the control area.
15. At the end of the experiment, the power supply is disconnected from wall and the laser head is disconnected from the power supply.
16. The equipment is appropriately stored away at secured location.
17. The laser safety light is turned OFF. Laboratory doors are unlocked.

F.7 Laser Alignment Guidelines

1. Unauthorized personnel are to leave the room.
2. Post appropriate area warning signs during alignment procedures.
3. Alignments shall be done by properly trained and authorized personnel. **Only one person at a time should adjust any optical component. Others should stand behind the person making the adjustments to avoid casual exposure to dangerous beams**.
4. Turn on the "LASER IN USE" warning light. The laboratory door is to be locked for controlled access.
5. Laser alignment shall not be initiated unless all precautionary measures are in place.
6. Check that the interlock on the door accessing the laboratory is secure, if applicable.
7. Use low-power visible lasers for path simulation of higher power visible or invisible lasers whenever possible.
8. Wear appropriate PPE (e.g. safety glasses, laser safety goggles, lab coats) during alignment. Use special alignment eyewear when circumstances (e.g. wavelength, power, etc.) permits.
9. When aligning invisible (e.g. UV, IR) beams, use beam display devices such as image converter viewers or phosphor cards to locate beams.
10. Perform alignment tasks using high-power lasers at the lowest possible power level.
11. Use a shutter or beam block to block high-power beams at their source except when actually needed during the alignment process.
12. Use a laser rated beam block to terminate high-power beams downstream of the optics being aligned.
13. Use beam blocks and/or laser protective barriers in conditions where alignment beams could stray into areas where uninvolved personnel are present.
14. Place beam blocks behind optics (e.g.: turning mirrors) to terminate beams that might miss mirrors during alignment.
15. Locate and block all stray reflections before proceeding to the next optical component or section.
16. Make sure all beams and reflections are properly terminated before high-power operation.
17. After aliment is completed the laser is turned OFF.
18. All unauthorized personnel are now allowed to enter the control area.
19. The laser safety light is turned OFF. Laboratory doors are unlocked.

Appendix G: Other Programs under Purview of the UNLV Radiation Safety Office

The University of Nevada, Las Vegas (UNLV) Radiation Safety Office is responsible for the Laser Safety Program in all Schools and Programs of the University. A Laser Safety Officer (LSO) is appointed to fulfill the requirements of the American National Standards Institute (ANSI) Z 136 standards and to oversee the implementation of the Program.

When necessary, the UNLV Radiation Safety Office and LSO may, with the approval of the Laser Safety Advisory Committee, appoint a qualified individual to act as an LSO and implement specialized Laser Safety Programs within certain Schools and Programs, to ensure safe operation of lasers and compliance with regulations. The LSO will provide this individual with a formal letter that recognizes such appointment, and also outlines an appropriate Delegation of Authority to administer the designated Program, and to stop immediately any activity that endangers safety, or that might result in a violation of regulations.

However, the ultimate responsibility for the Laser Safety Program remains with the UNLV Radiation Safety Office and the Department of Risk Management and Safety.

The person appointed as described must immediately inform the UNLV LSO of any laser incident that involves or might involve:

- inappropriate exposure to laser light;
- significant changes in SOPs;
- acquisition, transfer, disposal, or loss of a registered laser;
- any violation of regulations, or of the policies of the UNLV and the School or Program's Laser Safety Programs.

This is in addition to any other regulatory reporting requirements.