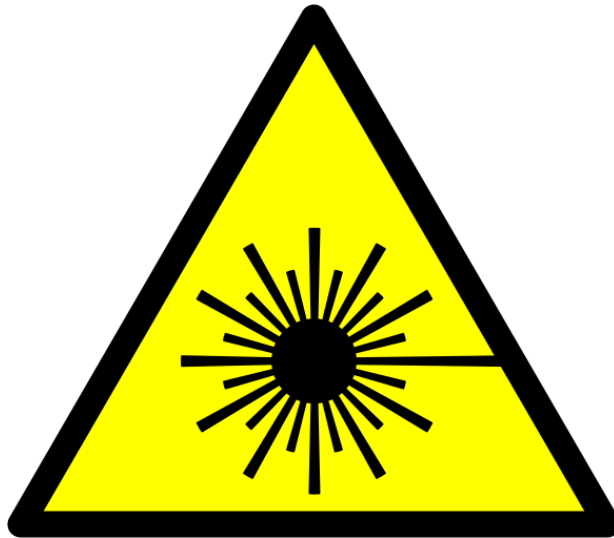


Laser Safety Manual



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THE
UNIVERSITY
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1. Introduction

The Radiation Safety Office oversees individuals who are using registered lasers at the University of Rhode Island (URI) including faculty, staff, students, researchers, and visitors. Those individuals using registered lasers at URI must strictly comply with federal and state regulations, standards, and university policies which is important for the safety and protection of all individuals at the University.

The Radiation and Laser Safety Committee (RLSC), under the functional authority of the President, is responsible for the Radiation Safety Program outlined in this manual and represents official university policy on radiation and radioactive materials. The purpose of the Laser Safety Manual (Separate manuals for Radioactive Materials Safety and X-ray Safety) is to assist all individuals in complying with the applicable regulations, standards, and the URI Radiation Safety Program.

Lasers are capable of causing injuries to eyes and skin. Class 3B lasers are capable of causing eye injuries from the direct beam and specular reflections. Class 4 lasers are capable of causing injuries from direct beam, specular and diffuse reflections, burning exposed skin, igniting flammable materials, and generating hazardous air contaminants.

Although lower classes of lasers (Class 1, 1M, 2, 2M, and 3A or 3R) are not subject to this manual and policy, their use is subject to other applicable requirements of the American National Standard Institute (ANSI). Users of lasers must ensure safe use. Please consult with the Radiation Safety Officer/Laser Safety Officer (RSO/LSO) if additional information is needed.

This Manual is not intended to be a fully comprehensive reference but is to ensure the safe use of lasers at URI. To achieve this goal, URI has adopted applicable regulations and the most recent ANSI for Safe Use of Lasers, ANSI Z136.1 which is recognized as a minimum standard for laser safety and widely used by regulatory agencies including The Food and Drug Administration (FDA) and The Occupational Safety and Health Administration (OSHA). Additional hazards associated with lasers such as high voltage, high pressure, noise, radiation and toxic gases due to laser operations are also mentioned in this manual. Further advice concerning hazards associated with specific laser and/or the development of new and unfamiliar procedures should be obtained through consultation with the RSO/LSO.

The Laser Safety Manual is an enforceable component of the URI's Radiation Safety Policy and violations of its policies and procedures are citable as areas of non-compliance by the Radiation Safety Office.

This manual has been submitted and approved by the RLSC and replaces all previous such documents. The RSO/LSO will submit a copy of the revised manual to the RLSC for approval when the revised manual has substantial changes.

The format and administrative content of the forms associated with this manual can be revised and new forms may also be added as necessary. However, changes which would result in any condition of non-compliance with applicable regulations or standards shall not be approved.

Where existing or future federal, state, or local regulations and the University policies are found to be different from the requirements contained in this manual, those legally accepted regulations shall supersede this document.

2. Telephone Numbers and Information

Environmental Health and Safety	(401) 874-7993
Environmental Health and Safety (Emergency)	(401) 874-2121
Environmental Health and Safety (Fax)	(401) 874-9069
Radiation Safety Office	(401) 874-2600
Radiation Safety Officer	(401) 874-9439
Health Physicist	(401) 874-9451
URI Health Services	(401) 874-2246
URI Public Safety (Emergency)	(401) 874-2121
URI Public Safety (Non-Emergency)	(401) 874-4553
Medical Emergencies	911

Radiation Safety Office hours are Monday through Friday, 8:30 a.m.-4:30 p.m.

For assistance with a radiation incident during normal office hours, call the Radiation Safety Office at 401-874-2600. In the event of an after-hours radiation incident, contact the URI Public Safety emergency line at 401-874-2121.

3. Laser Classification

Laser Classifications referenced from ANSI Z136.1.

Class 1

- Considered to be incapable of producing damaging radiation levels during operation
- Exempt from any control measures of other forms of surveillance
- Previously as Class 2A under the Federal Laser Product Performance Standard (FLPPS)
- Incorporated into consumer or office machine equipment
- Visible and invisible

Class 1M

- Considered to be incapable of producing damaging radiation levels during operation unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or a telescope (collimated beam)
- Exempt from any control measures other than to prevent potentially hazardous optically aided viewing and is exempt from other forms of surveillance
- Visible and invisible

Class 2

- Safe for accidental viewing
- Produces radiation that could cause eye damage after direct, long term exposure
- Hazardous only if viewer overcomes natural aversion response such as longer than 0.25 seconds
- Visible Only
- Maximum Continuous Wave (CW) limit is 1 milliwatt (mW)

Class 2M

- Safe for accidental viewing
- Produces radiation that could cause eye damage after direct, long term exposure
- Hazardous only if viewer overcomes natural aversion response such as longer than 0.25 seconds
- Highly divergent or large diameter beam
- Optically aided viewing exceeds Class 2 but lower than Class 3B
- Visible Only

Class 3R (formerly 3A)

- Operates between 1 mW and 5 mW if visible or up to 5 times Class 1 in infrared (IR) and Ultraviolet (UV) spectra region
- “R” stands for Reduced Requirements
- Replaces Class 3A from older standards
- Potentially hazardous under direct and specular reflection viewing conditions, but is normally not a diffuse reflection or fire hazard

Class 3B

- Produces radiation powerful enough to injure human eye tissue with 1 short exposure to the direct beam or its direct reflections off a shiny surface (specular reflection)
- Does not produce hazardous diffuse reflections under normal use
- Not usually capable of causing serious skin injury
- Operate between 5 mW and 500 mW

Safety Precautions

- Laser signage must be on the door or area
- Must complete the laser safety training
- It is recommended to have visual or sound alarm when laser is in use
- Must have Standard Operating Procedures (SOP) for each laser(s) and users must understand and follow the SOPs
- Permit only experienced personnel to operate the laser
- Enclose the beam path as much as possible
- Even a transparent enclosure will prevent individuals from placing their head or reflecting objects within the beam path
- Eye wear is needed for all individuals working within the controlled area
- Beam stop must be used at the end of the useful beam paths
- Operate the laser only in a restricted area or approved area
- Place the laser beam path well above or well below the eye level of any sitting or standing observers whenever possible
- Lasers should be mounted firmly
- Always use proper laser eye protection for the laser in use unless it is completely enclosed
- Have key switch or computer login activation to prevent tampering by unauthorized use
- Remove all unnecessary mirror-like surfaces from within the vicinity of the laser beam path

Class 4

- Operates above 500 mW
- Is hazardous to the eye or skin from the direct beam and may also pose a diffuse reflection or fire hazard

- May also produce laser generated air contaminants (LGAC) and hazardous plasma radiation

Safety Precautions

- Class 3B safety precautions and;
- It is required to have a visual or sound alarm when laser is in use
- Should only be operated within a localized enclosure or in a controlled workplace
- If a complete local enclosure is not possible, interlocking of room or area, or using a barrier at the room or the area entrance
- It is required to have a physical key switch
- Beam stop must be used at the end of the useful beam paths and fire resistant target materials must be used

ANSI Z136.1 emphasizes that “It must be recognized that this classification scheme relates specifically to the laser device and its potential hazard, based on operating characteristics. However, the conditions under which the laser is used, the level of safety training of persons using the laser, and other environmental and personnel factors are important considerations in determining the full extent of safety control measures.”

4. Individual Responsibilities

Authorized User (AU)

1. Ensuring compliance with the University's approved laser safety manual regarding Class 3B and 4 lasers.
2. Specific laser safety training for laser(s) including operating and alignment procedures, and supervising laser(s) use in the laboratory.
3. Implementing and enforcing the safety recommendations and requirements outlined in this manual.
4. Developing SOPs for the laboratory and obtaining approval of the SOP from the RSO/LSO.
5. Ensuring that all lasers in the laboratory are properly classified and labeled.
6. Registering all Class 3B and 4 lasers with the Radiation Safety Office.
7. Contacting the Radiation Safety Office to ensure users complete laser safety training prior to laser use.
8. Notifying the RSO/LSO immediately in the event of an injury caused by exposure to a laser.
9. SOPs must be readily available to users and placed near laser(s).
10. Notify the RSO/LSO for stolen, lost, or missing Class 3B or 4 lasers immediately when discovered.

Laser User

1. Following laboratory SOPs and working safely.
2. Notifying the AU in the event of an exposure incident as well as of injuries.
3. Completing laser safety training.

Radiation Safety Office

1. Developing a laser safety manual and policies and revising them when necessary.
2. Conducting safety audits of registered Class 3B or 4 laser laboratories at least annually.
3. Providing assistance in evaluating and controlling hazards.
4. Maintaining records of all registered Class 3B or 4 laser operations including inventory.
5. Conducting laser safety training for all personnel working with registered Class 3B or 4 lasers.
6. Participating in accident/incident investigations involving lasers.

Radiation Safety Officer (RSO) / Laser Safety Officer (LSO)

The University RSO/LSO is a designated staff member who has the knowledge and responsibility to apply appropriate laser radiation protection rules, standards, and practices. The RSO/LSO is named and specifically authorized to perform duties specified on this manual and the American National Standards Institute (ANSI) Z136.1. In addition to the items listed above, the following list of duties also pertain to the RSO/LSO:

1. Assumes control and has the authority to institute corrective actions including shutdown of operations when necessary in emergency situations or unsafe conditions.
2. Specifies whether any changes in control measures are required following any service and maintenance of lasers that may affect the output power or operating characteristics or whenever deliberate modifications are made that could change the laser class and affect the output power or operating characteristics.
3. Inspects and ensures the proper use of protective eyewear and other safety measures.
4. Ensures compliance with the laser requirements and with any engineering or operational controls required by the University, ANSI, and other applicable regulations.
5. In situations where engineering controls may not be adequate, the RSO/LSO must specify alternate controls to obtain equivalent laser safety protection.
6. Within 24 hours of discovery of an injury, reports to the appropriate agency each injury involving registered Class 3B or 4 lasers at the University.
7. Within 24 hours of discovery of a stolen, lost, or missing laser, reports to the appropriate agency any incident involving registered Class 3B or 4 lasers at the University.
8. Reports in writing to the regulatory agency within 30 days from notification of the events specified above 6 and 7.

5. Training and Qualifications

Only trained personnel are permitted to use laser(s). The AU will identify laser users based on departmental training, technical training and other appropriate learning experience.

All faculty, staff, and students operating registered Class 3B and Class 4 lasers are required to attend laser safety training conducted by the Radiation Safety Office prior to working with lasers, or provide an applicable training certificate or proof of training to the Radiation Safety Office. Before operating a registered Class 3B or 4 laser, faculty, staff and students shall:

1. Review and acknowledge the Laser Safety Manual.
2. Review the SOP for the specific laser to be used. Most laser equipment is provided with instructions for safe operation by the manufacturer; however, at URI, a standalone SOP for each laser in use is required for Class 3B and 4 lasers. Please contact the RSO/LSO for assistance in developing an SOP.
 - a. Approved SOPs for all registered Class 3B and 4 lasers must be available for review during laboratory and laser equipment audits. These SOPs must be maintained with the laser equipment for reference by the operator and maintenance or service personnel. Contact the RSO/LSO for a standardized SOP Laser Template.
3. Receive training from the AU or laboratory supervisor covering safe operation of the specific laser(s) to be used, administrative procedures, alignment procedures and other applicable SOPs.

6. Laser Procurement Procedures

Notify the RSO/LSO at (401) 874-2600 prior to purchasing, fabricating, or acquiring Class 3B and/or 4 lasers as well as for modifications to existing lasers. This is necessary to ensure that the system or unit can be safely installed and operated at designated locations. To ensure personnel safety and compliance with applicable policy and standards, laser use areas may require special design considerations depending on the laser hazard classification.

Transferred equipment and donations also require contacting the Radiation Safety Office for approval. The RSO/LSO will verify that the receiving Authorized User (AU) are authorized to use the lasers.

Laser safety devices should be purchased along with the laser, and installed with the laser when received. Failure to plan and install safety devices as required will delay use of the laser.

When notifying or consulting with the RSO/LSO, the following items must be included:

1. Laser, Type, Model, Hazard classification
2. Brief Description or Copy of Brochure/Manual (electronic preferred)
3. User contact information including use location

7. Laser Use Authorization, Amendment, and Record Keeping

Laser Use Authorization Application

All Class 3B and 4 lasers are required to be registered with the University's Radiation Safety Office. Classes 1, 2, and 3a (3R) lasers are not required to be registered.

Possession and use of all Class 3B and 4 lasers at the University must also be approved by the RSO/LSO and authorized by the RLSC.

Any Authorized User (AU) wishing to possess lasers for the first time at the University must complete the Laser Use Application and submit to the Radiation Safety Office by mail or by e-mail for review by the RSO/LSO. This application must include information on all lasers, laser users, equipment locations, and procedures. Anyone not listed on the authorization permit must not be allowed to work with lasers for any reason. The lasers must not be used until final approval is given by the RSO/LSO.

The use of lasers often requires layers of safeguards. Investigative procedures vary widely as do applicable safety techniques. The information provided on the application will enable the RSO/LSO to recommend necessary safety measures and assist the AU in implementing these measures. It is important that all items are filled in and the application fully completed. Radiation Safety Personnel shall perform compliance inspections prior to laser use (post installation inspection).

The RSO/LSO will present applications to the RLSC for authorization. The RSO/LSO may give interim approval to AUs until the RLSC's approval if necessary. A temporary authorization permit will be issued with the RSO/LSO's signature until the RLSC authorization is obtained at which time a final permit will then be issued.

Approved AUs will receive an Authorization to Use Lasers, which is proof of authorization at the University and may be submitted with Research Grant Proposals. Once authorized, the AU will remain authorized until either voluntary authorization termination by the AU or the authorization is revoked by the RLSC for noncompliance.

Laser Authorization Amendment Guidelines

AUs planning to make a change to their authorization must complete a Laser Authorization Amendment Form and submit it to the RSO/LSO for review. These changes may include the following:

1. Addition or removal of a Class 3B or Class 4 laser
2. Addition or removal of an authorized use location
3. Addition or removal of an authorized laser use procedure
4. Any change from the original Laser Authorization Application that was not previously approved

The Laser Authorization Amendment form and instructions can be obtained by contacting the Radiation Safety Office.

University Inventory and Record Keeping Requirements

The University is required to inventory all registered Class 3B and Class 4 lasers in their possession at an interval **not to exceed one year**. The laser inventory will typically be completed during the annual laser safety audit conducted by the Radiation Safety Office.

The RSO/LSO is required to maintain records of receipt, transfer, and disposal of all registered Class 3B and Class 4 lasers including:

1. Manufacturer's Name
2. Model and Serial Number of the laser
3. Date of receipt, transfer, and disposal
4. Name and address of person laser(s) received from, transferred to, or disposed by

Based on the above information, it is important that AUs notify the RSO/LSO immediately of any changes to their laser inventory (including making, selling, leasing, transferring, or lending lasers) or laboratory personnel.

8. Laser Use on Animals and Humans

Laser Use on Animals

Research using radiation producing devices on animals must be approved by the URI Institutional Animal Care and Use Committee (IACUC) as required by Regulations. The Radiation Safety Office requires AU to have an IACUC approval or a submitted IACUC application at the time of submitting the laser use application.

Laser Use on Humans

The following applies to all AUs and laser users intending to use lasers on humans:

1. Individuals must not use lasers on humans unless they are authorized as a licensed practitioner registered with the Rhode Island Department of Health (RIDOH). Lasers must be used under the supervision of a licensed practitioner of the healing arts and within the scope of practice of his/her professional license.
2. Individuals shall not be intentionally exposed to radiation above the maximum permissible exposure (MPE) levels unless as authorized by a licensed practitioner of the healing arts.
3. Exposure of an individual for training, demonstration or other non-healing arts purposes is prohibited unless authorized by a licensed practitioner of the healing arts.
4. Exposure of an individual for the purpose of research is prohibited, except as authorized in research studies. Research using radiation producing devices on humans must be approved by the URI Institutional Review Board (IRB) as required by Regulations. The IRB protocol must include at least one practitioner of the healing arts to direct use of the laser.
5. Documentation of laser equipment calibration and maintenance must be maintained for inspection by the Radiation Safety Office and/or any external regulatory agents.
6. AUs overseeing such activities must have an SOP for each activity to verify that such activities are conducted by board licensed practitioners with proper credentials.
7. Any medical event or injury/death of an individual requires notifying the Radiation Safety Officer and the RIDOH.
8. AUs intending to use lasers on humans must coordinate with the RSO/LSO.

9. Laser Receipt, Setup, Documents, Use, and Laboratory Design Guidelines

Receipt, Setup, Documents, and Use

The RSO/LSO must be notified when a laser arrives and when it is set up. The RSO/LSO must document installation, report to the RLSC, and maintain user authorization information. Radiation Safety personnel will provide assistance to any AU as needed. Laser operations except during the setup process is not permitted until the Radiation Safety Office has inspected and approved the laboratory set-up and safety provisions.

The RSO/LSO will require copies of specific documentation for review. Copies of these documents are required to be submitted to the RSO/LSO by mail or by e-mail. All records should be clearly identified, organized, and maintained in one location in the lab. This will assist the AU and the University to maintain compliance with applicable standards and regulatory requirements.

Documentation:

- Equipment Manuals
- Purchase records
- Receipt/Installation records (Includes transfers or donations, both internal and external)
- SOP for each laser including but not limited to start-up and shut-down, safety device by-pass, alignment, and emergency information
- Laser Safety glasses information
- Engineering Controls/Safety devices (interlocks, warning lights, etc.) information
- Calibration, maintenance, and modification records
- Other information as requested

Radiation Safety personnel will inspect the laser setup before operation begins. The AU may only turn on the laser for test procedures in the initial setup. All safety devices must be installed and operational. The laser must not be used fully without the final approval of the RSO/LSO. The RSO/LSO will grant final approval for use upon full compliance.

Lasers must also be inspected by Radiation Safety personnel at initial installation, after a move, and whenever maintenance or modifications affect the beam output or laser hazard classification. It is the responsibility of the AU to notify the RSO/LSO immediately in the event of the above actions. Door signage will always be supplied and posted by the Radiation Safety Office. Please call the Radiation Safety Office at (401) 874-2600 if laser signage is missing, defaced or needs updating.

Design Guidelines for Class 3B and 4 Laser Laboratories

This section will assist AU and Project Managers in the design, construction and renovation of Class 3B and 4 laser laboratories at the University.

The guidelines comply with requirements specified in the most current edition of ANSI Z136.1. In some cases, the design will be modified based on the AUs research proposal. If the laser classification intended for use is not specified by the researcher, Class 4 standard design guidelines should be followed. If the AU intends to use a Class 4 laser in the future, this design guideline will save costs of future remodeling. Design considerations include hazard warning signage on entryway, Controlled Entry (Access Control), Laser Beam Containment Curtain, Control Circuit, and Laboratory Layout. Additional design considerations covered in ANSI Z136.1 include, protection from Toxic Plumes and Laser Generated Effluents, Liquids in the Laboratory, Cable Runs, and Optical Benches. Contact the Radiation Safety Office for further assistance on laser facility design.

Guidelines for Laser laboratories Changes and Services

Changes and services in a laser laboratory should be done properly and in a safe manner in coordination with the AU and laser users. These include laboratory relocation, modifications, maintenance, and housekeeping. Special considerations must be given for laser equipment moves, transfers, or disposal.

All obsolete lasers and/or laser radiation labeled equipment should also be disposed of in coordination with the RSO/LSO by means of an amendment. The AU must also submit an amendment application to delete a closed lab from their authorization.

The Radiation Safety Office will verify that the labs are completely cleared of laser equipment and all signage is removed prior to close out.

AUs authorized to obtain and use laser devices leaving URI must contact the Radiation Safety Office to process the transfer of the laser devices. The AU must send a written notice to the RSO/LSO with the expected departure date from URI at least 2 weeks prior to departing. The Radiation Safety Office will audit the location at the final date of occupancy or within 2 business days to clear and release to the applicable University department.

All work with lasers must be stopped during a modification or maintenance operation. Direct support and supervision by laboratory personnel should be provided as needed for facilities or external contractors. Custodial personnel or routine maintenance workers must also be given specific instructions on how and when such work can be performed for their safety.

10. Laser Safety Requirements for Class 3B and 4 Lasers

The URI laser safety program is mainly for safety guidance for research and educational activities involving lasers and especially for Class 3B and 4 lasers. The fundamental objective is to ensure exposures are at or below the laser specific MPE. The MPE is defined as the level of laser radiation to which an unprotected person may be exposed without any adverse biological changes in the eye or skin.

For the purpose of this manual, operations are to be performed by AUs and laser users listed on the AU's authorization permit. Maintenance activities must be performed by the AU or designated laser users specified on the SOP. Service functions must never be performed by the AU or laser users, unless they are qualified and certified to perform such functions and can demonstrate qualifications and certifications through documentation.

Control measures used to prevent exposure to laser radiation above MPE are outlined below.

Protective Housing

Each laser shall have a protective housing that prevents unauthorized human access during the operation of the laser and collateral radiation that exceeds the MPE which is the limit of Class 1 laser exposure.

Protective housings or service panels enclosing embedded Class 3B and 4 lasers shall be interlocked or fastened closed requiring special tools for removal. When it is necessary to remove protective housings or service panels, a temporary laser controlled area shall be established. A temporary laser controlled area must be provided to protect personnel within and outside the area. Requirements for the temporary laser controlled area include, but are not limited to:

- Restricted access to the area.
- Control of the beam to prevent the beam and reflections from extending beyond the area.
- Removal of reflective materials in and near the beam path.
- Appropriate laser eye protection if there is a possibility of exposure to laser radiation above the MPE.
- A warning sign posted outside the area. (See the Signs, Labels, and Posting for Lasers below for the warning sign requirements)
- Notification of the Radiation Safety Office if setting up a temporary controlled area.

Safety Interlocks

A safety interlock must be provided for any portion of the protective housing to ensure that laser radiation is not accessible above the MPE limits. This includes that safety interlocks cannot be removed or displaced during normal operation or maintenance, thereby allowing access to radiation above the MPE limits.

Adjustment during operation, service, testing, or maintenance of a laser containing interlocks shall not cause the interlocks to become inoperative or the laser radiation to exceed MPE limits outside the protective housing except where a laser controlled area is established.

For pulsed lasers, interlocks shall be designed so as to prevent turning on of the laser. For continuous wave (CW) lasers, the interlocks shall turn off the power supply or interrupt the beam such as with shutters.

An interlock must not allow automatic accessibility of radiation emission above MPE limits when the interlock is closed. Multiple safety interlocks must be provided if failure of a single interlock would allow human access to high levels of laser radiation.

Beam Control

The beam height must be well above or below the normal eye position of a person in a standing or seated position. Position the laser so that the beam is not directed toward doorways or aisles. Securely mount the laser system to maintain the beam in a fixed position during operation and limit beam movements during adjustments. Ensure beam path is well defined and controlled. Beam stop must be used at the end of its useful path.

Confine beams and reflections to the optical table. The addition of beam-stopping panels to the sides of the optical table is recommended if reflections are expected. If the beam path extends beyond the optical table, a physical barrier must be used to prevent accidental exposure. Have only diffuse reflection materials in or near the beam path, where reasonable. Absorbing unwanted reflections and scatter is not permitted unless necessary for research purposes and this must be described in the SOP and approved by the RSO/LSO.

Infrared (IR) Lasers

The beam from an IR laser shall be terminated in a fire-resistant material where necessary. Inspection intervals of the material and actions to be taken in the event or evidence of degradation shall be specified in the laboratory SOP.

Ultraviolet (UV) Lasers

Exposure to UV radiation shall be minimized by using beam shields including specific UV safety glasses and clothing which attenuate the radiation to levels below the MPE for the specific UV wavelengths.

Nominal Hazard Zone (NHZ)

In the presence of unenclosed Class 3B and Class 4 laser beam paths, an NHZ must be established. If the beam of an unenclosed Class 3B and Class 4 laser is contained within an area by adequate control measures to protect personnel from exposure to levels of radiation above the appropriate MPE, that area may be considered to be the NHZ.

Viewing Optics and Windows

All viewing ports, viewing optics, or display screens included as an integral part of an enclosed laser or laser product must incorporate safety devices such as interlocks, filters, or attenuators, to maintain the laser radiation at the viewing position at or below the applicable MPE under any conditions of operation of the laser.

All collecting optics, such as lenses, telescopes, microscopes, endoscopes, etc., intended for viewing use with a laser must incorporate safety devices such as interlocks, filters, or attenuators, to maintain the laser radiation transferred through the collecting optics to levels at or below the appropriate MPE. Normal or prescription eyewear is not considered collecting optics.

Warning Systems

Each Class 3B or Class 4 laser, or laser products shall provide visual or audible indication during the emission of accessible laser radiation. For Class 3B and Class 4 lasers, this indication shall be sufficient prior to emission of laser radiation to allow appropriate action to avoid exposure. Any visible indicator shall be clearly visible through protective eyewear designed specifically for the wavelength(s) of the emitted laser radiation. If the laser and laser energy source are housed separately and can be operated at a separation distance of greater than two meters, both laser and laser energy source must have incorporated visual or audible indicators independently. The visual indicators shall be positioned so that viewing does not require human access to laser radiation in excess of the MPE.

Controlled Area

For Class 3B or Class 4 lasers, a controlled area shall be established when exposure to the laser radiation in excess of the MPE or the collateral limits is possible. Each controlled area must be posted by proper laser signage and access to the controlled area must be restricted. All laser system components must be contained within the laser controlled area.

Class 3B Laser-Controlled Area

- Only trained users in the operation of the laser and laser safety must be permitted to operate the laser or laser system.
- An individual knowledgeable in laser safety must directly supervise the laser-controlled area such as an AU or a designated trained laser user.
- The area shall be posted with the appropriate warning signs and have restricted access.
- Beam must be controlled to prevent any misdirected beams or reflections.
- Provide eye protection for all personnel working in the area.
- Cover all windows and other openings to prevent laser radiation from extending beyond the laser-controlled area.

Class 4 Laser-Controlled Area

In addition to all of the requirements for a Class 3B laser-controlled area, one of the following entryway controls must be incorporated for a Class 4 laser.

- **Non-Defeatable Entryway Safety Controls:** Non-defeatable safety latches or interlocks that deactivate the laser or reduce the output to levels below the MPE in the event of unexpected entry are the preferred method of entryway control.
- **Defeatable Entryway Safety Controls:** If the above control is not practical, defeatable entryways safety controls may be used. Defeatable entryway controls allow authorized personnel to override the controls. Defeatable entryway controls may be used only if there is no laser radiation hazard at the point of entry. Personnel must be properly trained and provided with adequate personal protective equipment.
- **Procedural Entryway Controls:** If both of the above safety controls are not practical, procedural entryway controls may be used. When procedural entryway controls are used, the following conditions must be met:
 - All laboratory personnel must be trained by the AU and such training documentation should be maintained.
 - Personal protective equipment must be provided.
 - A door, barrier, screen or curtain(s) must be used to block or diffuse the laser radiation below the MPE at the entryway.
 - The entryway must be equipped with a lighted laser warning sign that indicates that the laser is operating.

For Class 4 indoor controlled areas, when experiments require continuous operation, the user in charge of the controlled area must be permitted to momentarily override the safety interlocks to allow access to other users if it is confirmed and verified that there is no laser radiation at the point of entry, and if necessary protective devices are being worn by the entering personnel.

When the removal of panels or protective covers and/or overriding the interlocks becomes necessary, such as for servicing or maintenance, and accessible laser radiation exceeds the MPE and the collateral limits, a temporary controlled area shall be established.

Key Control

Class 4 lasers shall incorporate a physical key-actuated master control. Class 3B lasers shall incorporate a physical key-actuated or computer-actuated master control. Computer-actuated master controls must have passwords and users must log-off when the system is not in use. The key shall be removable and the Class 3B and Class 4 laser shall not be operable when the key is removed. When not in operation or unattended, the key will be removed from the device and stored in a location away from the machine.

Eye Protection

Protective eyewear must be worn by all individuals with access to Class 3B and/or Class 4 laser radiation. Protective eyewear devices shall provide:

- Comfortable and appropriate fit all around the area of the eye
- Be in proper condition to ensure the optical filter(s) and holder retain all protective properties during use
- Provide the required optical density (OD) or greater at the specific wavelengths and energy involved
- The OD with associated wavelengths(s) permanently labeled on the filters or on the eyewear
- Eyewear must be examined at intervals not to exceed 12 months to ensure the reliability of the protective filters and integrity of the protective filter frames

Unreliable eyewear shall be removed from use and discarded. This includes any eyewear that is damaged (scratched lenses), broken, or not functioning as intended.

Contact the Radiation Safety Office for assistance in determining appropriate optical density for laser eyewear as well as for eyewear inspection.

Skin Protection

For Class 4 lasers, when there is a possibility of exposure to laser radiation that exceeds the MPE limits for the skin, appropriate use of protective gloves, clothing, or shielding is required.

Confocal Microscopes

Laser scanning confocal microscopes are generally Class 1 laser systems that contain embedded Class 3B or Class 4 lasers, however generally not certified as a Class 1 system. When the confocal microscope is used as intended, no control measures are necessary. However, AUs must attend the laser safety training and other users must attend the laser

safety training for confocal microscope users. Laser scanning confocal microscopes still need to be registered with the Radiation Safety Office for inventory, audit and training purposes. If the exterior of a confocal microscope is labeled as Class 3B or 4, then the applicable requirements for the Class of the embedded laser must be followed.

If the protective housing is removed for alignment, maintenance or service activities, a temporary laser-controlled area must be established and control measures appropriate to the class of the embedded laser shall be implemented.

Controls for Non-Beam Hazards

- Electrical Hazards - The use of lasers or laser systems presents an electric shock hazard. Most lasers contain high-voltage power supplies and capacitors or capacitor banks that store lethal amounts of electrical energy. Exposures may occur from contact with energized components and these exposures most often occur during set up, installation, maintenance, modification and service when protective covers are removed.
 - To reduce electrical hazards especially when removing protective housings or covers, and potentially exposing energized components, the following measures must be followed:
 1. Enclose high voltage sources and terminals whenever possible.
 2. Turn off power and ground all high voltage points before working on power supplies.
 3. Verify that each capacitor is discharged and grounded prior to working near the capacitor.
 4. Do not wear rings, watches or other jewelry when working with or near electrical equipment.
- Laser-Generated Air Contaminants (LGAC) - Air contaminants may be generated when Class 4 and some Class 3B laser beams hit a target. The quantity, composition, and chemical complexity of the LGAC depend on the target material, cover gas, and beam irradiance. Materials such as plastics, composites, metals, and tissues may release carcinogenic, toxic and noxious air contaminants. Ozone is produced around flash lamps and can build up with high repetition rate lasers. Special optical materials used for far infrared windows and lenses may also release hazardous air contaminants.

Concentrations of LGAC must be maintained below the exposure limits specified by OSHA, The National Institute for Occupational Safety and Health (NIOSH) or The American Conference of Governmental Industrial Hygienists (ACGIH). There are three major control measures to reduce the concentration of LGAC to acceptable levels:

1. Use local exhaust ventilation to remove the LGAC at the point of generation. Local exhaust ventilation should be vented to the outside.
2. Isolate the process whenever possible.

3. Respiratory protection shall be used only when engineering controls are not practical. The Radiation Safety Office and The Environmental Health and Safety (EH&S) must be contacted prior to wearing a respirator.
- Fire Hazards – Class 4 laser beams can ignite flammable solvents, gases and combustible materials. Some Class 3R and Class 3B lasers can be a fire hazard in certain conditions. To reduce fire hazards:
 1. Terminate laser beams with non-combustible materials.
 2. Bring only necessary materials into the laser area.
 3. Store flammable and combustible solvents and materials properly and away from the laser beam.
 4. If a filter is used, the filter must be cleaned or replaced according to the manufacture's recommendation.
 - Explosion Hazards - High-pressure arc lamps, filament lamps and capacitor banks may explode if they fail during operation. The laser target and elements of the optics may shatter during operation. To reduce explosion hazards:
 1. Enclose high-pressure arc lamps and filament lamps in housing that can withstand an explosion if the lamp disintegrates.
 2. Enclose the laser target and optics in protective housing during laser operation.
 3. Ensure that capacitors are equipped with current-limiting devices and are shielded.
 - Compressed Gas - Hazardous gases are used in some laser applications including chlorine, fluorine, hydrogen chloride and hydrogen fluoride. Fill gases used for optical tables are highly pressurized and hazardous when released. Storage of gas cylinders must follow EH&S guidelines. For more information, contact the EH&S at (401) 874-7993.
 - Laser Dyes and Solvents - Laser dyes are organic compounds that are dissolved in a solvent to form a lasing medium. Some dyes are highly toxic or carcinogenic. Most solvents suitable for dye solutions are flammable and toxic by inhalation and/or skin absorption. For more information, contact the EH&S at (401) 874-7993. The following measures must be followed when working with dyes:
 1. Obtain safety data sheets (SDS) for all dyes and solvents prior to working with them.
 2. Prepare and handle dye solutions in a working fume hood.
 3. Use disposable bench covers and wear a lab coat, safety glasses and appropriate gloves.
 4. Pressure test all dye laser components before using dye solutions. Pay particular attention to tubing connections.
 5. Install spill pans under pumps and reservoirs.

Signs and Postings

The laser area must be conspicuously posted with signs to notify individuals of the type of hazards present. All access points to a laser controlled area with Class 3B or Class 4 lasers must be posted with approved laser warning signs.

Laser hazard signs are provided and installed by the Radiation Safety Office. Contact the Radiation Safety Office for additional or replacement signs or postings.

- Light Indicated Warning Signs - Entrances to laboratories where Class 4 open beam lasers are present must have a lighted warning sign or light that is activated when the laser is energized. A warning sign or light also can be manual.
- Written Warning Signs - The following warning signs are required to be posted at the entrances to laboratories where lasers are present:
 1. All laboratories where a Class 3B or Class 4 laser is present must have an appropriate sign. The sign on the door(s) must conform to ANSI Z136.1.
 2. Laboratories with a Class 3A or Class 3R laser that generates a beam with an irradiance or radiant exposure equal to or greater than the MPE shall also have a “Danger” sign affixed to the door(s). If a user doesn’t know the output power, the user must contact the RSO/LSO to measure output power to determine if signage is needed.
 3. All laboratories where a Class 2 and Class 3A or Class 3R laser except specified Class 3A and Class 3R above is present do not require signs however users can request signs by contacting the Radiation Safety Office.
 4. The outside boundary of a temporary laser controlled area shall be posted with a Notice sign that conforms to ANSI Z136.1. The Notice sign must indicate the reason for the temporary controls, the precautionary instructions or protective actions required, the type of laser or the wavelength, the pulse duration (if applicable), the maximum output and the class of the laser.

Labels

Lasers shall be properly labeled as follows:

1. All Class 2, Class 3a or 3R, Class 3B and Class 4 lasers and laser systems shall have a label conspicuously affixed to the housing that conforms to ANSI Z136.1. The label shall show the precautionary instructions or protective actions required, the type of laser or the wavelength, the pulse duration (if applicable), maximum output and the class of the laser or laser system. The label shall incorporate the laser symbol. Manufacturers are required to label lasers in accordance with the Federal Laser Product Performance Standard (21CFR1040.10.) These labels satisfy this requirement. Contact the Radiation Safety Office for label specifications if the laser was not labeled by the manufacturer, or if it was modified or built in the laboratory.
2. All removable protective housings must have a label affixed in a conspicuous location that conforms to ANSI Z136.1. The label shall indicate the hazard of the enclosed laser. This label does not need to contain the laser symbol. Contact the Radiation Safety Office for label specifications.

11. Injury or Medical Event

AUs and users must immediately seek medical attention for the injured individual and notify the RSO/LSO within 24 hours at (401) 874-2600 or (401) 874-2121 (after hour emergency) of any exposure injury involving a laser registered at URI. Any incidents involving lasers must be reported to URI human resources.

The RSO/LSO must be notified within 48 hours of any non-injury incident (near miss) which involves potential exposure to laser radiation exceeding the MPE. A written summary of an injury or non-injury incident must be forwarded to the RSO/LSO within a week (5 working days) following the incident. Records of incidents shall be maintained by the AU and the RSO/LSO.