Laser Safety Manual

University of Guelph
Human Resources
Environmental Health and Safety

Prepared by:
Radiation Safety Officer(s)
Approved by the Radiation Safety Committee
May 2021

UNIVERSITY of GUELPH

IMPROVE LIFE.

Table of Contents

UNIVERSITY of GUELPH

IMPROVE LIFE.

REVISION HISTORY

Revisions to the Laser Safety Manual are to be documented in the table below. All amendments are to be made by the RSO or their delegate and are to be approved by the Radiation Safety Committee prior to being incorporated into the manual.

Revision and Annual Review History

Revision Number	Revision or Review	Document Section	Details of Amendments	Date
0			Creation of LSM	2018
1	Revision	Various		May 2021

1. Introduction

The term "LASER" is an acronym for **Light Amplification by Stimulated Emission of Radiation**. Laser is a non-ionizing form of electromagnetic radiation and hence cannot ionize biological tissue an most mediums it traverses through. However, due to the concentrated nature of the power output, high powered lasers pose a significant hazard to the operating personnel and surrounding environment. Lasers can cause severe eye injuries leading to permanent blindness along with burns and can also be a fire hazard. Therefore, control measures must be implemented to mitigate the risks associated with high power lasers.

The purpose of this manual is to outline the policies and procedures concerning the use of lasers at the University of Guelph to:

- Prevent personal injury resulting from exposure to laser radiation through the implementation of safe work practices, proper signage, and training.
- Conform to the requirements of the Ontario Ministry of Labor, the American National Standard for Safe Use of Lasers (ANSI Z136.1), the American National Standard for Safe Use of Lasers in Research, Development, or Testing (ANSI Z136.8), and related regulations and standards. Relevant laser standards are outlined in Table 1.

Table 1: Safety standards published by ANSI.

Standard	Purpose
ANSI Z136.1	Safe Use of Lasers
ANSI Z136.3	Safe Use of Lasers in Health Care
ANSI Z136.4	Recommended Practice for Laser Safety Measurements for Hazard Evaluation
ANSI Z136.5	Safe Use of Lasers in Educational Institutions
ANSI Z136.8	Safe Use of Lasers in Research, Development, or Testing

1.1 Scope

The scope of this manual document is to define the specific guidelines for the implementation of a Laser Safety Program for the use of Laser devices (Class 3B and Class 4 specifically) within at the University of Guelph. The module is manual outlines the regulatory and safety requirements during registration, operation and decommissioning phase of laser devices.

The Laser Safety Program is administered by the office of Environmental Health and Safety and managed by the Radiation Safety Officer(s). The Radiation Safety Officer assumes the responsibilities of the Laser Safety Officer for the University of Guelph. The organizational chart for the Laser Safety Program is outlined in Appendix A.

2. Roles and Responsibilities

In addition to the roles and responsibilities as outlined in Radiation Safety Manual sections. This section outlines the additional roles and responsibilities for the Radiation Safety Officer (RSO), Principal Investigator/Permit Holder and Laser Worker.

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

The Radiation Safety Officer assumes the role of the Laser Safety Officer (LSO) and is responsible for management of the Laser Safety Program at the University of Guelph. For consistency, the University Radiation Safety Officer is referred to as the Radiation Safety Officer in this manual. The roles and responsibilities for the Radiation Safety Officer include:

- Establish and maintain adequate policies and procedures for the control of laser hazards in compliance with applicable requirements, including federal, provincial and local regulations.
- Maintain inventory of all Class 3B and Class 4 lasers.
- Evaluate the hazards of laser work areas, including the establishment of verification of the extent of Nominal Hazard Zones.
- Implement and maintain prescribed control measures including approving alternate control measures.
- Recommend and approve proper PPE for laser workers.
- Ensure the proper use and maintenance of laser-specific PPE.
- Review the signage and equipment labels.
- Review laser installations, facilities, and equipment before use, including modifications.

- Provide adequate safety education and training are provided to laser personnel.
- Refer class 3B/4 laser operators to the medical surveillance program offered by Occupational Health & Wellness (OHW).
- Develop a response plan for incidents of actual or suspected exposure to potentially harmful laser radiation, including provisions for medical assistance, incident investigation, and documentation and reporting of investigation results to the Radiation Safety Committee.
- Approve laser operation once control measures are adequate, including SOP for maintenance and service of enclosed systems utilizing Class 3B or 4 lasers and operational procedures for Class 3B and 4 lasers and adequate consideration of safety from non-beam hazards.
- Issue permits and bring concerns to the Radiation Safety Committee as deemed necessary.
- Communicate medical surveillance requirements to University of Guelph personnel who may be involved in use of Class 3B or 4 lasers

Identify to OHW University of Guelph personnel who may be involved in use of Class 3b or 4 lasers and provide confirmation to personnel that work with lasers may proceed once the safety requirements are fulfilled.

2.2 Principal Investigator

A Principal investigator (PI) is the permit holder for Class 3B and Class 4 lasers and is responsible for the safe day-to-day operations of the laser. Each principal investigator will be assigned a permit for laser use, and it is the responsibility of the Principal Investigator to oversee the operations under that permit.

The principal investigator has the following responsibilities:

- To register all Class 3B or Class 4 lasers or laser systems with Environmental Health and Safety department via RSO and seek RSO approval of the facility before commencing operations
- Maintain Laser Safety Training records.
- To provide the names of laser workers working with Class 3B and Class 4 lasers to the RSO and OHW for training and medical surveillance scheduling, respectively. To advise laser workers of the medical surveillance program for baseline ophthalmology testing offered

through OHW and to engage such workers to participate in the program. To not permit the operation of a laser unless all controls are properly functioning to guard the safety of workers, visitors, and the general public.

- To not permit operation of a new or modified Class 3B or Class 4 laser or laser system under his/her authority without the approval of the RSO. To submit plans for new Class 3B or Class 4 laser installations or modifications to the RSO for approval.
- To confirm that laser workers have completed laser safety training prior to working with or in proximity of Class 3B or Class 4 lasers or laser systems.
- To confirm that each laser worker is trained in the safe operation of the specific Class 3B or Class 4 laser or laser system that he/she will operate.
- To permit only trained and authorized workers to operate or work in proximity of Class 3B or Class 4 lasers or laser systems.
- To confirm that all engineering controls are in place and all administrative procedure controls are followed.
- To confirm and enforce the use of appropriate personal protective equipment when and/or where required.
- To confirm that all Class 3B or Class 4 lasers or laser systems are securely stored or disabled (for example by removal of the key) when not operating to prevent unauthorized use
- To confirm that all laser workers and supervisors participate in the University's related medical surveillance program.
- To confirm that any observers are properly informed and protected from potential hazards.
- To report any actual or suspected accidents or incidents to EHS.
- Prohibit identified laser workers from commencing work until notification has been received from OHW that baseline ophthalmology results have been received.
- To cooperate with the RSO during laser safety inspections and correct any unsafe conditions in a timely manner.

To limit observers within a laser-controlled area which contain a Class 3B laser and not permit observers within a laser-controlled area which contains a Class 4 laser unless appropriate approval from the principal investigator has been obtained, the degree of hazard and avoidance procedures has been explained, and appropriate protective measures are taken.

2.3 Laser Operator

A laser operator is defined as a person who operates Class 3B or Class 4 laser equipment, this includes any beam alignment and maintenance responsibilities.

Laser operators have the following responsibilities:

- To obtain Laser Safety training prior to operating or working in proximity to Class 3B or Class 4 laser/laser systems.
- To not energize or work with or near a laser unless authorized by the principal investigator.
- To comply with all safety rules, practices, requirements, written SOP and other procedures prescribed by the principal investigator and the RSO.
- To be familiar with all operational procedures and specific safety hazards of the Class 3B or Class 4 laser/laser systems that he/she will operate or work with.
- To operate Class 3B and Class 4 laser/laser systems only under the conditions authorized by the principal investigator
- To report all unsafe conditions to the principal investigator
- To participate in the University's medical surveillance program.
- To immediately report any known or suspected accidents to the principal investigator. If the principal investigator is not available, the worker shall notify the RSO.
- To limit observers within a laser-controlled area which contain a Class 3B laser and prohibit observers within a laser-controlled area which contains a Class 4 laser unless appropriate approval from the principal investigator has been obtained, the degree of hazard and avoidance procedures has been explained, and appropriate protective measures are taken.

3. Classification of Lasers

Lasers are categorized into four main classes with sub-classes according to their energies and subsequent biological and environmental impact. Table 2 defines the different classes of lasers along with their biological and environmental impacts.

Table 2: Classification of Lasers

Laser Class	Description	Control Measures & Hazards
Class 1	Considered to be incapable of producing damaging radiation levels during operation.	Exempt from any control measures or any other forms of surveillance.
Class 1M	Considering to be 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 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.
Class 2	Has maximum energy of 1 mW and emits radiation in the visible portion of the electromagnetic spectrum (0.4 to 0.7 µm).	Exempt from any control measures apart from direct viewing of the beam. Eye protection can be ensured by the aversion response (i.e., blinking).
Class 2M (Magnification)	Has maximum energy of 1 mW and emits radiation in the visible portion of the electromagnetic spectrum (0.4 to 0.7 µm).	Exempt from any control measures unless viewed with optical aids. Eye protection can be ensured by the aversion response (i.e., blinking).
Class 3R (Reduced risk)	Has energies greater than 1 mW but less than 5 mW. Can be visible or invisible.	Exempt from any control measures. Class 3R laser system is potentially hazardous under direct and specular reflection viewing conditions provided the eye is appropriately focused and stable. However, the probability of an actual injury is small.
Class 3B (Medium power)	Has energies between 5mW and 500mW. Can be visible or invisible.	Class 3B can be hazardous under direct and specular reflection viewing conditions but is normally not a diffuse reflection or fire hazard. Safety procedures need to be implemented while working with class 3B lasers.
Class 4 (High power)	High powered lasers and have energies above 500mW. Can be visible or invisible.	Class 4 is a hazard to the eye or skin from the direct beam and may pose a diffuse reflection or fire hazard. Some of the class 4 lasers can also produce laser generated air contaminations (LGAC).

As seen in Figure 1, the eye injury hazard from a given laser increases as a function of its energy. Therefore, users must be aware that any laser over 5 mW can be a significant eye hazard and as such Class 3B and 4 lasers must be registered with the Environmental Health and Safety department by contacting the Radiation Safety Officer.

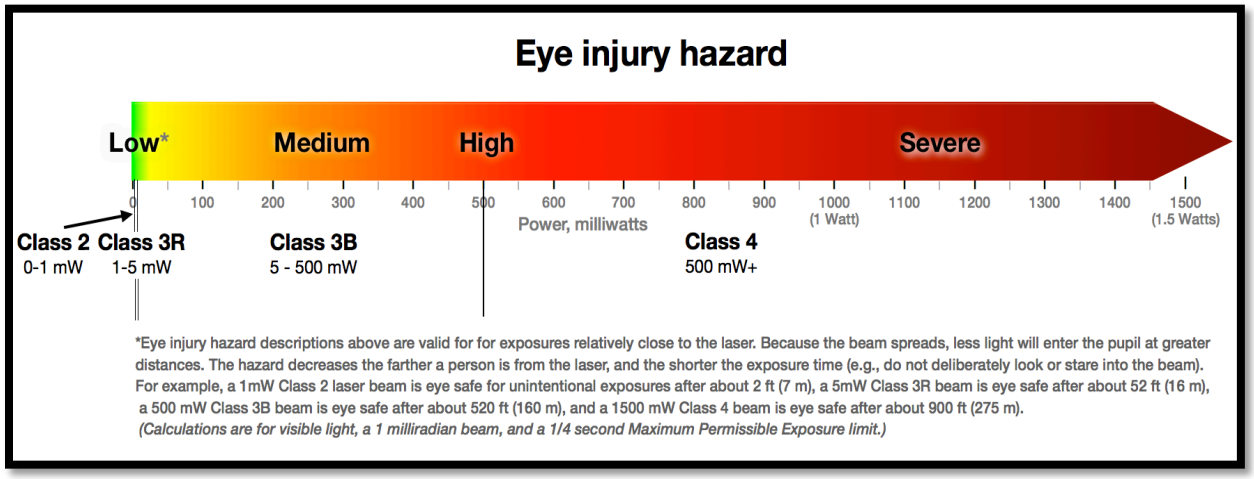


Figure 1: Eye Injury Hazard as a function of Laser Energy

4. Laser Registration & Hazard Evaluation

All Class 3B and 4 lasers at the University of Guelph must be registered with the department of Environmental Health and Safety prior to their operation. It is the responsibility of the Principal Investigator to register the laser/laser system with the RSO in order to perform an appropriate hazard analysis to determine necessary safety control in order to mitigate any risks associated with the device.

The purpose for registration of all Class 3B and Class 4 lasers and laser systems and maintain an inventory is:

- To identify lasers and laser systems, for which appropriate engineering and/or administrative or procedural controls may need to be implemented.
- To be used as a basis for periodic laboratory laser safety inspections for compliance with the University's Laser Safety Program,

- To help identify all personnel who routinely work around hazardous laser beams and need to be protected by engineering controls, administrative procedures or both.
- To help identify those who must participate in medical surveillance, review and approval of safety systems by RSO before commencing the operations.

Note: *it is recommended that principal investigators consult with the RSO prior to purchasing any laser systems to ensure they are approved for use in Canada.*

As part of the registration process, the following information must be provided by the Principal Investigator to register the laser prior to the installation of the laser.

- Principal Investigator's name and contact information
- Department
- Laser location (building and room number)
- Laser class
- Laser gain medium and type
- Laser category (commercial, research-built, component, subassembly, etc.)
  Intended application (e.g., research, veterinary medical, teaching, etc.)

Please refer to **Appendix B** for the Laser Registration form. The form must be completed and submitted to the Radiation Safety Officer whenever a new Class 3B or Class 4 laser is acquired.

4.1 Laser Hazard Evaluation

The registration of a Class 3B or Class 4 open beam lasers **must** be coordinated with the Radiation Safety Officer to correctly assess the Maximum Permissible Exposure (MPE) and establish the Nominal Hazard Zone (NHZ). In addition, special ventilation provisions may be required for some laser sources due to the possibility of production of Laser Generated Air borne Contaminants (LGAC). The concepts of MPE, NHZ, and LGAC are explained further in the following sections. A sample of the laser hazard evaluation form can be found in **Appendix E.**

4.1.1 Maximum Permissible Exposure

The term maximum permissible exposure (MPE) defines the highest power or energy density of a light source that is considered safe for use. MPE is the maximum exposure allowed

to the operating personnel without causing any inadvertent eye or skin injury. The MPE needs to be calculated for open beam Class 3B or Class 4 lasers such that an appropriate plan can be established for the safe use of the laser.

As per the regulations, the MPE limit is set at the 10% of the dose that has a 50% chance of creating damage. Furthermore, MPE is dependent on the energy/wavelength of the source beam. Figure 2 shows the relationship between MPE limits for cornea and exposure time at various wavelengths. International Electro-Technical Commission (IEC-60825) and ANSI-Z136.1 standard includes guidelines on how to calculate MPE's.

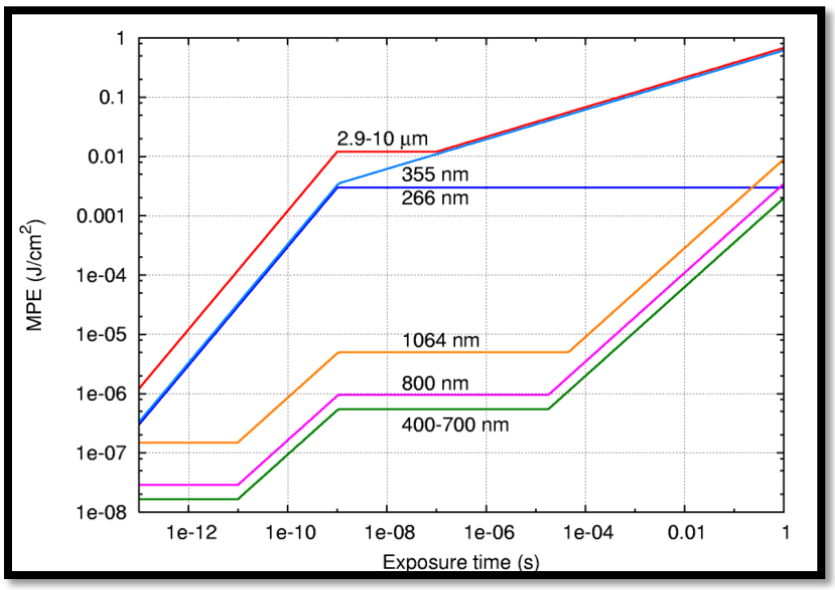


Figure 2: MPE vs Exposure Time at different wavelengths

Before setting up any open beam Class 3B or Class 4 laser rooms it is imperative to that the MPE from the laser is well below injury threshold. The MPE will be calculated by the Radiation Safety Officer in conjunction with the Principal Investigator. For cases where the MPE cannot be reduced below the recommended guidelines, a Nominal Hazard Zone analysis is required to establish a Nominal Hazard zone (NHZ).

4.1.2 Nominal Hazard Zone

A nominal hazard zone is defined as the area around the laser where the MPE is exceeded. Within these areas special measures need to be taken. Each time a laser with an

open beam setup (Class 3B or Class 4) is registered; a NHZ analysis will be performed by the RSO to confirm that laser operators and non-operating personnel are protected when working within or outside the NHZ. The workers safety will be protected by setting up laser curtains or barriers, using personal protective equipment and beam stops. Figure 3 shows an example of NHZ for a given laser.

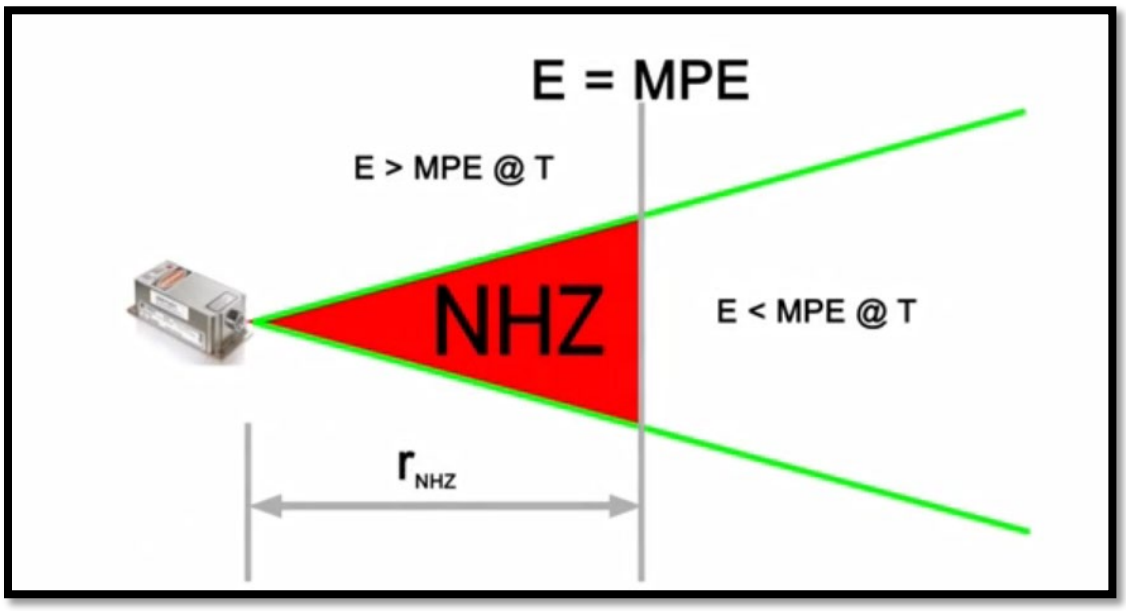


Figure 3: Example of Nominal Hazard Zone

4.1.3 Laser Generated Airborne Contaminants (LGAC)

Some Class 3B or Class 4 lasers are powerful enough to react with the material to produce airborne contaminants which can pose a hazard to the operating personnel. These airborne contaminants are referred to as LGACs. LGACs result from the interaction of the laser beam with target or other materials and can include metallic fumes and dust, chemical fumes and aerosols containing biological contaminants.

These contaminants are normally produced when target irradiance reaches 107 W/cm^2 and hence local area ventilation is required to keep the workers protected from LGACs.

5. University of Guelph Laser Safety Program

The quality of the laser safety program is maintained by implementing administrative and procedural controls along with the engineering controls. This adds on to redundancy and increases the overall effectiveness of the program

5.1 Administrative and Procedural Controls

Administrative controls are an integral part of the laser safety program and are implemented to increase awareness amongst the workers. Likewise, some procedural controls such as personal protective equipment are to be used whenever necessary as determined by the Radiation Safety Officer. Some of the examples of administrative and procedural controls includes medical surveillance, general and equipment specific training, personal protective equipment, and laser permitting/registration. Table 3 outlines the requirement for such controls depending on the type of laser used.

Table 3: Administrative and Procedural Controls Requirements:

Class	Administrative and Procedural Controls	Laser Safety Training	Medical Surveillance
1	Not Required	Not Required	Not Required
1M	Required	Application Dependent (2)	Application Dependent (2)
2	Not Required (1)	Not Required (1)	Not Required
2M	Required	Application Dependent (2)	Application Dependent (2)
3R	Not Required (1)	Not Required (1)	Not Required
3B	Required	Required	Recommended
4	Required	Required	Recommended

1) Not Required except for conditions of intentional intra-beam exposure applications.

2) Certain uses of Class 1M or 2M laser or laser systems that exceed Class 1 or Class 2 because they do not satisfy measurement condition 1 may require hazard evaluation and/or manufacturer's information.

5.1.1 Medical Surveillance

All Class 3 and 4B laser workers are required to complete a baseline eye exam and the attached document (Medical Surveillance-Lasers) outlines the policies and procedures pertaining to the medical surveillance for laser use at the University of Guelph. See the Medical Surveillance – Radiation Lasers. It is the responsibility of the principal investigator to identify the laser workers and report to the RSO.

5.1.2 Laser Safety Training

All laser operators (including Principal Investigators) and personnel working in a laser-controlled area must participate in the University's Laser Safety training course prior to working with Class 3B or Class 4 lasers. Laser users must participate in refresher training at least every 3 years. Passing the quiz with a mark of 75% or greater will suffice as having completed the refresher course. Laser Safety training is provided by the Environment Health & Safety Department at the University of Guelph.

In addition to general EHS laser safety training, users must also complete practical hands-on training for the equipment that they would be working with. It is the responsibility of the Principal Investigator to organize training and ensure no untrained individuals operate the device. All training records should be kept by the Principal Investigator and will be audited during routine inspections conducted by the RSO.

5.1.3 Personal Protective Equipment

All laser operators working with Class 3B, or Class 4 lasers are always required to wear eye protection when present in the Nominal Hazard Zone (NHZ). The PI is responsible for providing appropriate laser safety eyewear to all laser operators that attenuates all wavelengths emitted by the laser system. Determination of the proper Optical Density (OD) for the corresponding devices is done in consultation between the PI and RSO.

The shielding capability of the eyewear is defined by its Optical Density (OD) rating. The rating is dependent on the wavelength and the energy of the laser beam. OD is defined by the degree to which a refractive medium attenuates the transmitted ray of light. Furthermore, Optical

density is inversely proportional to transmittance hence higher the optical density rating of the eyewear, lower the transmittance of the light and the more protective the eyewear will be. Table 4 explains the relationship between optical density and transmittance. For example, laser eyewear with an OD of 5 would only allow 0.001% of the total incident rays of light to pass through.

5.1.4 Determining Optical Density (OD)

To determine the necessary optical density required for specific laser and laser systems, the following relationship is commonly used,

$$OD = \log_{10} \frac{P_d}{MPE}$$

Where P_d is the irradiance (W/m^2), and *MPE* is the Maximum Permissible Exposure (W/cm^2) and can be found in **Appendix D**. If the irradiance for a specific laser is not known, it can be calculated using,

$$P_d = P/A$$

Where *P* is the power of the beam (W), and *A* is the cross-sectional area of the beam or pupil (cm^2).

Table 4: Relationship between Optical Density and Transmittance.

OD	Transmittance	OD	Transmittance
0.0	100%	**5.0**	0.001%
1.0	10%	**6.0**	0.0001%
2.0	1%	**7.0**	0.00001%
3.0	0.1%	**8.0**	0.000001%
4.0	0.01%	**9.0**	0.0000001%

5.1.5 Access Control

Each lab housing a Class 3B or Class 4 laser must maintain a strict access control policy with access limited to authorized personnel only while the lasers are in use. Access to the lab may be limited by either an electronic access card or a key. For shared labs, all personnel to be present during operation of the laser, must participate in laser safety training.

All labs housing open beam Class 3B or Class 4 lasers must also take active measures to prevent inadvertent exposure to the people who may look into the lab through windows/doors. All the windows as well as reflective surfaces in the room shall be covered with non-reflective material to eliminate the possibility of eye injury from specular radiation.

5.1.6 Laser Hazard Signage

All the rooms and areas containing Class 3B and 4 lasers that are designated as the nominal hazard zone (NHZ) are to have the appropriate laser hazard signage posted directly outside the entrance to the space. All laser hazard signage must comply with the guidelines provided by the ANSI standards and must contain the following information for each laser contained in the space:

a) Language containing warning information regarding the potential hazards in the laser-controlled area,
b) Class of the laser(s),
c) Type of laser(s)
d) Wavelengths emitted by the laser(s),
e) Optical Density (OD) for safety glasses required to enter the laser-controlled area,
f) Max power of the laser.

Laser safety signage can be requested from the RSO or can be provided by the PI/lab supervisor that the approved format is satisfied. Figure 4 shows the templates for the two types of approved laser signage.

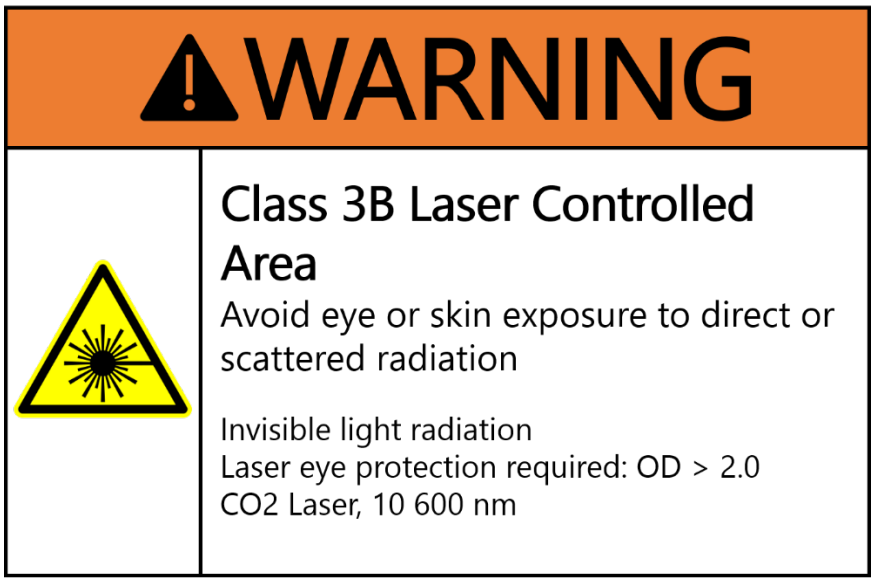


Figure 4: Laser hazard signage typically used for Class 3B lasers.

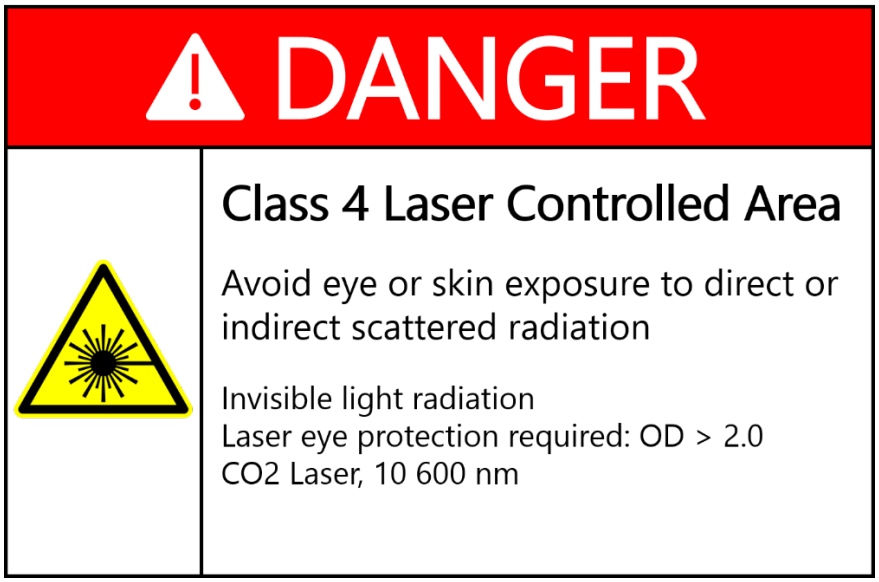


Figure 5: laser hazard signage typically used for Class 4 lasers.

5.1.7 Laser Permits and Inspections

An internal permit will be issued by the Radiation Safety Officer on behalf of the Department of Environmental Health and Safety once a new Class 3B or Class 4 laser is registered. The permit will be valid until the end of the laser's life and will be updated if there is any amendment made to

the operations or location. A copy of the internal permit should be kept in the approved location where a laser is to be used.

Furthermore, it should be noted that compliance must always be maintained, and each internal permit is subject to routine internal inspections. The RSO has the authority of revoking or amending the permit provided compliance is not maintained.

To maintain compliance and validity of permits, routine inspections will be conducted by the Radiation Safety Officer. The inspection schedule for lasers is based on the risk profile of the lab i.e., open beam vs closed beam. Labs with Class 3B or 4 open beam lasers will be inspected on annual basis while the Class 3B or 4 closed beam laser labs will be inspected once every three years. Please refer to Appendix C for a sample copy of the Laser Permit.

Table 5 provides a list of various Administrative and Procedural controls that may be needed for different Laser types as per ANSI Z136.1.

Table 5: ANSI Z136.1 Recommendations on the use of different administrative and procedural controls.

Administrative and Procedural Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Standard Operating Procedures	-	-	-	-	-	X	X
Output Emission Limitations	-	-	-	-	-	RSO Determination	
EHS Training	-	X	o	X	o	X	X
Authorized Personnel	-	*	-	*	-	X	X
Protective Equipment	-	*	-	*	-	X	X
Spectators	-	*	-	*	-	X	X
Window Protection	-	-	-	-	-	X	X
Warning Signs and Labels	-	-	o	o	o	X	X
Skin Protection	-	-	-	-	-	X NHZ	X NHZ

Legend
X, Shall
o, Should
*, May Apply with use of optical aids
NHZ, Nominal Hazard Zone Analysis Required

5.2 Engineering Controls

This chapter explores some of the engineering controls that need to be implemented while using Class 3B or Class 4 lasers.

5.2.1 Protective Housing

A protective housing can be defined as a physical barrier that prevents the release of laser radiation more than the MPE. As per the ANSI Z136.1, protective housing which enclose Class 3B or Class 4 lasers or laser systems shall be provided with an interlock system which is activated when the protective housing is opened or removed during operation or maintenance. The interlock or interlock system shall be designed to prevent access to laser radiation above MPE. A laser system without a protective housing is considered an open beam system and as such a NHZ analysis must be performed to ensure the safe operation.

5.2.2 Beam Stop Attenuator

Each Class 4 must be provided with a permanently attached beam stop or attenuator such that it limits the laser radiation below MPE when the beam is not required.

5.2.3 Key Control

All Class 4 lasers shall be provided with a master control in form of a key or an access code that needs to be activated prior to the operation of the laser thereby preventing unauthorized access of the laser.

5.2.4 Laser Curtains

Laser curtains are required for all open beam Class 3B and 4 lasers and are a type of protective barrier. The curtains are used to block direct and diffusely scattered laser radiation more than the maximum permissible exposure (MPE) limits from exiting into other areas. A barrier may be used at the entrance way to a dedicated laser laboratory, to cover windows, as a perimeter guard around all or part of an optical table or as advised by the Radiation Safety Officer.

5.2.5 Entry Interlocks and Warning Light

The entry to the laser area should be interlocked in such a way that the laser can only be engaged when the protective barrier is engaged completely (Example: Laser Safety Curtains shall be fully shut). Furthermore, there should be a warning light that should clearly display that the laser is currently in use.

5.2.6 Activation Warning Sounds

All Class 4 lasers are required to have an activation warning system in form of an audible alarm, a warning light or a verbal countdown during activation or startup of the laser. This is required so that personnel are aware of the laser use.

To summarize, Table 6 provides a list of various Engineering controls that may be needed for different Laser types as per ANSI Z136.1.

Table 6: Engineering Control Measures

Engineering Controls	Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing	X	X	X	X	X	X	X
Without Protective Housing	RSO shall establish alternative controls						
Interlocks on Removable Protective Housing	Δ	Δ	Δ	Δ	Δ	X	X
Key Control	-	-	-	-	-	o	X
Viewing Windows, Display Screens and Collecting Optics	Assure viewing limited <MPE						
Full Open Beam Path	-	-	-	-	-	X NHZ	X NHZ
Limited Open Beam Path	-	-	-	-	-	X NHZ	X NHZ
Enclosed Beam Path	None Required (Provided there is Protective Housing with interlocks)						
Activation Warning Systems	-	-	-	-	-	o	X NHZ
Indoor Laser Controlled Area	-	*	-	*	-	X NHZ	X NHZ

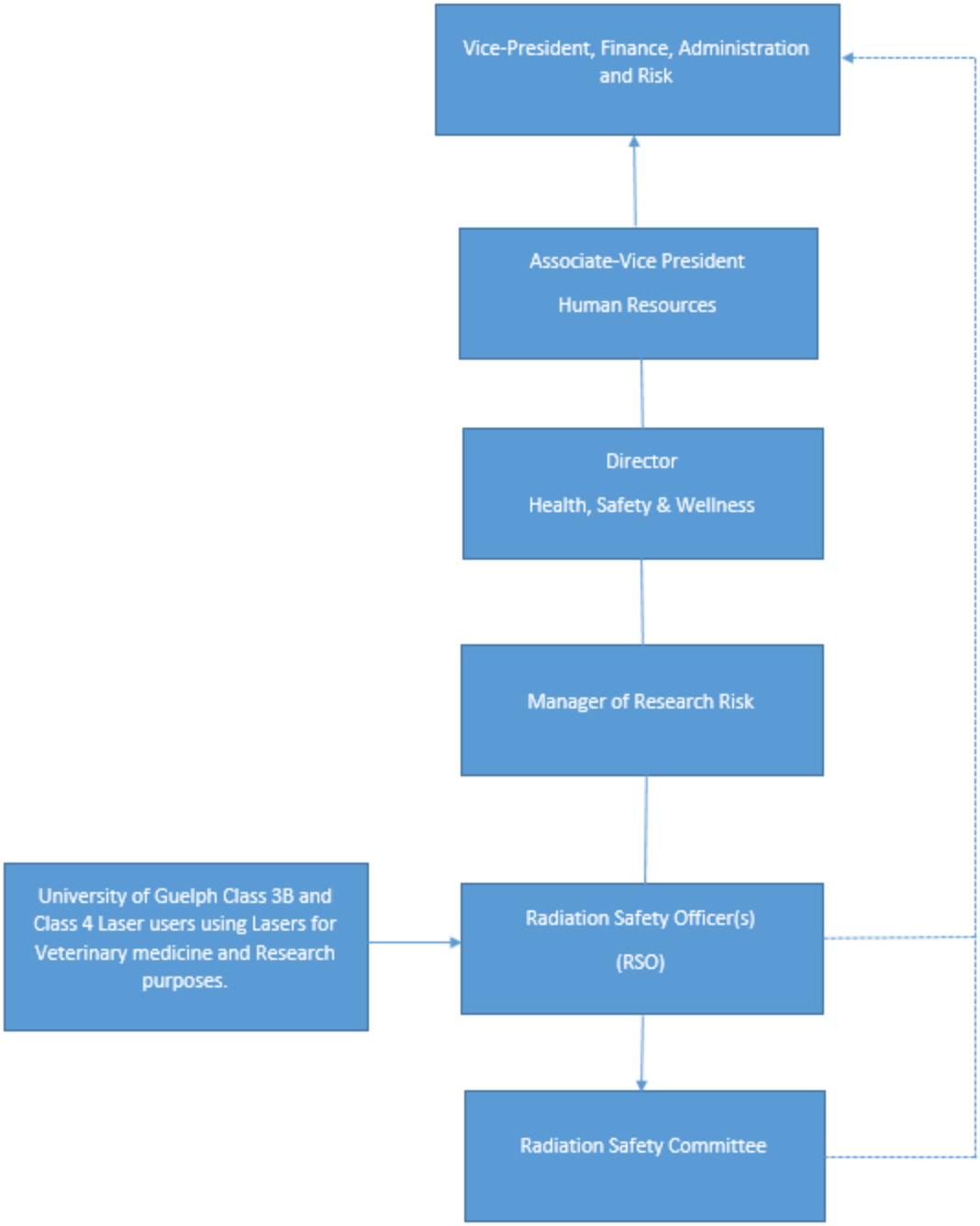
Legend
X, Shall
o, Should
*, May Apply with use of optical aids
Δ, shall if the enclosed laser is Class 3B or Class 4
NHZ, Nominal Hazard Zone Analysis Required

6. Decommissioning and Disposal

Whenever the permit holder is disposing of a Class 3B or Class 4 laser source, a decommissioning form is to be completed and submitted to the Radiation Safety Officer. It should be noted that a **written notice in the form of an email must be sent to the RSO (radsafe@uoguelph.ca) whenever equipment is to be disposed/decommissioned.** The disposal process will be coordinated by the RSO.

Before disposing off the laser, the power supply of the laser shall be severed such that it cannot be made operable again. Further damage to ensure that the Laser is inoperable may be required as deemed necessary by the RSO.

Appendix A: Radiation Safety Organizational Chart


Vice-President, Finance, Administration and Risk
Associate-Vice President
Human Resources
Director
Health, Safety & Wellness
Manager of Research Risk
University of Guelph Class 3B and Class 4 Laser users using Lasers for Veterinary medicine and Research purposes.
Radiation Safety Officer(s)
(RSO)
Radiation Safety Committee

Appendix B: Laser Registration Form

Laser Registration Form

Environmental Health & Safety
Alexander Hall 162 | 50 Stone Rd. E. | Guelph, ON
Contact: radsafe@uoguelph.ca

This form is intended to be used for registration of all Class 3B and Class 4 laser systems at the University of Guelph. Please submit all applications for registration to the RSO at radsafe@uoguelph.ca.

Applicant Information

Name:		**Date:**	
Office:		**Laboratory:**	
Phone:		**Lab Phone:**	
E-mail:			

Equipment Information

For continuous (CW) lasers

Manufacturer	Serial No.	Model	Class	Type	Wavelength (nm)	Maximum Power (J)	Beam Diameter (mm)	Beam Divergence (mrad)

For pulsed lasers

Manufacturer	Serial No.	Model	Class	Type	Wavelength (nm)	Energy per Pulse (J)	Pulse Duration (s)	Beam Divergence (mrad)

Proposed Use
Please provide a brief summary of intended use of the equipment

Appendix C: Laser Permit

IMPROVE LIFE.

Permit No:

Laser Equipment Permit

Environmental Health & Safety

Permit Holder	
PI Name	
Office	
E-mail	
Approved Users	

Laser Room Location	
Building	
Building Number	
Room Number	
Approved Device	
Laser Make	
Laser Serial Number	
Class	
Permit Validity	
Effective Date	
Expiry Date	
Beam Type	
Open or Closed Beam	
Required Safety Measures	
Approved Uses	

Permit Approved by:

_____ _____

Radiation Safety Officer *Date of Approval*

Appendix D: Table of Maximum Permissible Exposures (MPE)

Table C3a. Point Source MPE for the Eye for Selected CW Lasers

Laser Type	Wavelength (nm)	Exposure Duration (s)	Maximum Permissible Exposure ($J \cdot cm^{-2}$)	($W \cdot cm^{-2}$)
Argon	275	10 to 3×10^4	3×10^{-3}	–
Helium-Cadmium	325	10 to 3×10^4	1	–
Argon	351	10 to 3×10^4	1	–
Helium-Cadmium	441.6	0.25	–	2.6×10^{-3}
Argon	488	10 to 58	–	1×10^{-3}
	488	58 to 10^2	5.8×10^{-2}	
	488	$> 10^2$	–	5.8×10^{-4}
	514.5	10 to 3×10^4	–	1×10^{-3}
Helium-Neon	632	0.25	–	2.6×10^{-3}
Helium-Neon	632	10 to 3×10^4	–	1×10^{-3}
Krypton	647	0.25	–	2.6×10^{-3}
Krypton	647	10 to 3×10^4	–	1×10^{-3}
InGaAlP	670	0.25	–	2.6×10^{-3}
GaAs	905	10 to 3×10^4	-	2.6×10^{-3}
Neodymium: YAG	1064	10 to 3×10^4	-	5×10^{-3}
InGaAsP	1310	10 to 3×10^4	-	0.308
InGaAsP	1550	10 to 3×10^4	-	0.1
Carbon-Dioxide	10.6 μm	10 to 3×10^4	-	0.1

Appendix E: Laser Hazard Evaluation Form

IMPROVE LIFE.

Laser Hazard Evaluation

Environmental Health & Safety
University of Guelph

Complete all relevant fields for each new Class 3B and/or Class 4 laser. The following hazard evaluation can be conducted in consultation with the RSO.

General Information	
Principal Investigator	
Department	
Lab Room Number	
E-mail	

Technical Specifications		Comments
Manufacturer		
Model		
Serial Number		
Hazard Class (3B or 4 only)		
Type (lasing media)		
Wavelength(s) (nm)		
Output Power(s)		
Pulse Energy (J)		*If pulsed
Pulse Length (s)		*If pulsed
Repetition Rate (Hz)		*If pulsed
Beam Diameter (mm)		
Divergence (mrad)		
MPE (W/cm^2 or J/cm^2)		
Diffuse NHZ (m):		
Intrabeam NOHD (m):		
Minimum OD(s) per wavelength		

Warning Signs and Labels		Available? (Y/N)
Warning label(s) visible (on house and or control panel)		
Beam aperture label at beam port		
Warning label(s) on beam path enclosure (> 1 m long)		
Warning sign(s) visible at entrance		
Warning light assembly at entryway		
Key control for on/off switch (class 4); master switch		
Protective housing interlocks tested		
Protective housing intact		
If not:	Access restricted & area control	
	PPE (including eye protection) available	
	Barriers, beam stops	

UNIVERSITY of GUELPH
IMPROVE LIFE.

Protective Measures		Available? (Y/N)
ENGINEERING SAFETY CONTROLS		
Laser secured to table		
Laser optics secured to prevent stray beams		
Laser not at eye level		
Beam is enclosed		
Remote viewing of beam		
Fiber optics used		
Windows in room covered		
Reflective material kept out of beam path		
No physical evidence of stray beams		
BEAM HAZARDS		
Beam stops (present at end of all beam paths & non-combustible)		
Barriers/screens if present (non-combustible & no burn holes)		
Beam path enclosures if present		
Beam condensed or enlarged		
Beam focused		
Beam intensity reduced through filtration		
NON-BEAM HAZARDS		
Fire extinguisher available		
Emergency egress maintained		
Electrical Safety		
No exposed circuits (V > 50V)		
Insulation, cords, etc. in good condition		
"Power-up" warning lights clearly visible		
No wires/cables on the floor		
Optical table properly grounded		
Chemical Safety		
Dyes/Solvents (if used)	Dye/solvent_____	
	MSDS available	
	Double containment (spill tray, etc.)	
	Chemical PPE specified & available	
	Fume hood available	
Cryogens		
Compressed gases		
Collateral radiation hazard		
Explosion Hazard		
Fire Hazard		
LGAC Production		

Appendix F: Laser Safety Eyewear Guidelines

PIs/Supervisors are required to provide adequate protective eyewear for all laser operators working with Class 3B/4 laser systems. The following list gives general recommendations for laser safety eyewear approved for use at the University of Guelph.

Laser Safety Eyewear Recommendations:

1. Must be rated with adequate optical density (OD) for full range of wavelengths that can expose an operator.
2. The OD should be clearly marked on each pair of safety eyewear.
3. Eyewear rated for different wavelengths may be used for lasers tuned at multiple wavelengths, provided they protect against each individual output.
4. All laser operators and lab personnel working within a laser-controlled area must have access to protective eyewear when the laser source is ON.
5. It is recommended that eyewear such as goggles, and glasses use a wrap-around design that protects against accidental exposures and stray beams.

Example: How to read to read laser safety goggle/glasses OD rating

The goggles above provide protection for output between 840 nm and 950 nm with an optical density of OD 5 and up. They also provide additional protection for outputs between 950 nm and 1070 nm that require an optical density of 7 or greater.