Human Resources, Health, Safety and Employee Well-Being (HSEWB)

Laser Safety

Program

Initial release date: 2014

Last review date: April 2024

Contents

[1.0 Introduction and Objectives 3](#_Toc163652755)

[2.0 Scope 3](#_Toc163652756)

[3.0 Background 3](#_Toc163652757)

[4.0 Definitions 4](#_Toc163652758)

[5.0 Roles and Responsibilities 6](#_Toc163652759)

[6.0 Part A: Prevention and Education 11](#_Toc163652760)

[7.0 Part B: Procedures and Processes 15](#_Toc163652761)

[8.0 Reprisal 18](#_Toc163652762)

[9.0 Non-Compliance 19](#_Toc163652763)

[10.0 Record Keeping 19](#_Toc163652764)

[11.0 Reviewed By 19](#_Toc163652765)

[12.0 Related Policies / Programs / Procedures 19](#_Toc163652766)

[References 20](#_Toc163652767)

[Appendix A: Laser User Checklist 21](#_Toc163652768)

[Appendix B: Laser Safety Inspection Form 22](#_Toc163652769)

[Appendix C: Laser Components, Classification and Hazards 24](#_Toc163652770)

[Appendix D: Hazard Evaluation 31](#_Toc163652771)

[Appendix E: Engineering Control Measures for Four Classes 33](#_Toc163652772)

[Appendix F: Administrative and Procedural Controls for Four Classes 37](#_Toc163652773)

[Appendix G: Registration of Lasers – Permit Application 42](#_Toc163652774)

[Appendix H: Laser Safety Permit – List of Authorized Laser Users 44](#_Toc163652775)

[Appendix I: Emergency Contact Information 45](#_Toc163652776)

# 1.0 Introduction and Objectives

York University is committed to providing a safe learning and work environment. Lasers have been used on campus for laboratory/research purposes.

The objectives of the Laser Safety Program are to:

* Prevent personal injury resulting from the exposure to laser radiation through the implementation of effective controls for laser hazards such as, but not limited to, safe work practices, proper signage and education for workers; and
* Comply with the requirements of the Ontario Ministry of Labour, Immigration, Training, and Skills Development, the American National Standard for Safe Use of Lasers (ANSI Z136.1-2022) from the American National Standards Institute (ANSI) and related regulations and standards.

This program:

* Provides guidance for the safe use of lasers and laser systems for laboratory/research purposes;
* Describes accepted safe working practices and useful resource materials for laser users; and
* Outlines effective controls of laser hazards to assist researchers.

# 2.0 Scope

This program applies to all Class 3B and Class 4 laser and laser systems in controlled areas (indoors) at York University for non-human use and to all those identified as Principal Investigators, laser supervisors, laser users (i.e. staff, faculty, students) and workers in the proximity of these lasers.

# 3.0 Background

The acronym **LASER** stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

There are several classes of lasers, each with specific specifications and characteristics. Lasers are classified according to their potential to cause biological effects. Lasers are categorized from Class 1 to 4 with some subclasses (in accordance with the use of optical aids, etc.), and the potential to cause harm increases with the number. Class 3B and Class 4 lasers are deemed as higher powered lasers and have a greater potential to cause serious harm.

The information contained in this program is based on the American National Standard for the Safe Use of Lasers, ANSI Z136.1-2022. Although ANSI Z136.1-2022 is frequently cited, for more thorough guidance, the complete standard should be reviewed.

The basic elements of York University’s control program include:

1. Registration of all Class 3B and Class 4 laser/laser systems;
2. Implementing a laser safety permit system for all class 3B and class 4 laser labs;
3. The requirement for inspections of Class 3B and Class 4 laser/laser systems;
4. The requirement for training and education of laser users;
5. The requirement for reporting incidents involving all Class 3B and Class 4 laser/laser systems;
6. Provision of medical assessments;
7. The requirement for personal protective equipment;
8. The requirement for engineering controls;
9. The requirement for administrative and procedural controls; and
10. The requirement for auditing the implementation and effectiveness of the program.

An employer’s role in providing a safe workplace is included in Ontario’s *Occupational Health and Safety Act*. This legislation establishes the employees’ rights to, and employer’s obligations towards maintaining a healthy and safe workplace.

# 4.0 Definitions

**Employee:** All persons working for York University including faculty, staff, instructors, student workers, and anyone who is defined as a “worker” under *the Occupational Health and Safety Act.*

**Continuous Wave (CW):** The output of a laser, which is operated in a continuous rather than a pulsed mode. A laser operated with a continuous output greater than or equal to 0.25 s is regarded as a CW laser.

**Controlled Area:** An area where the occupancy and activity of those within are subject to control and supervision for the purpose of protection from laser hazards.

**Laser:** A device, which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to low energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.

**Laser Permit:** A York University document issued by Health, Safety and Employee Well-Being to all Principal Investigators who are in charge of open beam class 3B and/or class 4 lasers.

**Laser System:** Assembly of electrical, mechanical, and optical components, which includes one or more lasers.

**Laser System – Class 3B:** These are moderate power lasers (continuous wave: 5 - 500 mW). In general, Class 3B lasers will not be a fire or skin hazard. As well, they are not capable of producing a hazardous diffuse reflection except for conditions of intentional staring done at distances close to the diffuser. For further details, consult the ANSI Z136.1-2022.

**Laser System – Class 4:** These are high power lasers (continuous wave: >500 mW). In general, Class 4 lasers are hazardous to view under any condition (directly, specular or diffusely scattered) and are a potential fire and a skin hazard. For further details, consult the ANSI Z136.1-2022.

**Laser Supervisor:** An individual who has been delegated supervisory responsibilities by a Principal Investigator for Class 3B and Class 4 laser/laser systems and laser workers.

**Laser User:** One who operates a Class 3B or Class 4 laser/laser systems (e.g. one who performs the experiment, one who is being trained to use the laser system, etc.). The laser user must have full laser safety training.

**Laser Laboratory Worker:** One who works in the Nominal Hazard Zone but does not operate the laser (e.g. one who is preparing samples, performs computer work in the laser laboratory, etc.). The laser laboratory worker must have laser safety awareness training.

**Laser Safety Officer (LSO):** One who has the authority to effect the knowledgeable evaluation of laser hazards, and the authority to monitor and enforce the control of laser hazards.

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

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

**Optical Density (OD):** Logarithm to the base 10 of the reciprocal of the transmittance. The optical density (attenuation) at a specific wavelength shall be specified for laser protective eyewear.

**Principal Investigator (PI):** An individual who has charge of a laser laboratory and/or Principal authority for Class 3B or Class 4 laser/laser systems. Also called the Laser Permit Holder.

**Standard Operating Procedures (SOPs):** A written procedure that defines the standard way in which a laser or laser system will be operated.

**Healthy workplace:** Is one that actively works to: (1) prevent harm to an employee’s physical and psychological health and safety and (2) promote physical and psychological well-being.

**Workplace:** Where employees are assigned to or approved to perform work or such other university sanctioned activities. This includes the designated area where a worker performs work remotely.

# 5.0 Roles and Responsibilities

**Shared Responsibility - All York Community Members**

* Create, promote, and maintain a healthy and safe work environment;
* Abide by the requirements of this program and applicable procedure(s);
* Report any identified hazards to the appropriate area management; and
* Every effort must be made to work toward the resolution of complaints by all those affected.

**Dean**

* Identify all Principal Investigators under their authority and ensure that the Principal Investigators clearly understand their duties and responsibilities as individuals with principal authority for Class 3B and Class 4 lasers and laser systems;
* Ensure that all components of the York University Laser Safety Program are implemented in the department(s);
* Ensure adequate resources are made available to support controls; and
* Monitor the effectiveness of this program and applicable procedure(s) on an ongoing basis.

**Principal Investigator (PI)**

* Comply with and enforce standards set by regulatory and granting agencies, University policies, codes, terms and conditions of permits, as applicable;
* Ensure that all Class 3B and Class 4 lasers in their possession are registered with HSEWB and maintain an updated record of lasers in their possession;
* Identify all Class 3B and Class 4 laser supervisors and user/laboratory workers under their authority to the Laser Safety Officer (LSO). Refer to Appendix A for Laser User Checklist;
* Ensure that all administrative and engineering controls are in place or followed (e.g. presence of signage, usage of curtains/barriers/screens, etc.);
* Provide and ensure the usage of the appropriate personal protective equipment (e.g. gloves, lab coat, goggles, etc.);
* Complete Laser Safety Training offered by HSEWB.
* The PI has overall responsibility for ensuring that the laser workers working with Class 3B and Class 4 lasers are competent and have been trained in the operation concerned;
* Permit only trained personnel to operate or work in proximity to Class 3B or Class 4 lasers or laser systems;
* Provide sufficient site-specific training, instruction, and supervision to laser users/supervisors, and laboratory workers;
* Cancel laser supervisor/user/laboratory worker privileges until satisfied that they fully meet the requirements of this program;
* Conduct laser safety inspections at least on an annual basis;
* Report any known or suspected incidents related to the lasers under their control to HSEWB using a Workplace Incident Report (WIR);
* Report and investigate known or suspected incidents related to the lasers under their control to the LSO and/or the alternate LSO;
* Take appropriate action to rectify areas of non-compliance or any unsafe acts or conditions in a timely manner to ensure the safety of any authorized worker(s), authorized service personnel, or contractors;
* Inform the LSO when a laser is loaned to another lab at York University; and
* Inform the LSO about lasers that need to be decommissioned.
* The PI may delegate some or all of their responsibilities to a laser supervisor, however, the PI cannot discharge these responsibilities to a laser supervisor.

**Laser Supervisors**

* Responsible for complying with the requirements as stated for employer under the *Occupational Health & Safety Act*.
* Complete Laser Safety Training prior to operating or working in proximity to Class 3B or Class 4 laser/laser systems that they will operate/oversee.
* Be familiar with the general operating procedures and specific safety hazards of lasers under their control, and make available this information to the laser users under their supervision.
* Ensure that the users working with Class 3B and Class 4 lasers are competent and have been trained in the operation concerned.
* As directed by the PI, provide instruction and supervision to laser users.
* Provide sufficient site-specific training, instruction, and supervision to laser users, and laboratory workers.
* Provide and ensure the usage of the appropriate personal protective equipment (e.g. gloves, lab coat, goggles, etc.).
* Operate Class 3B and Class 4 laser/laser systems safety and in a manner consistent with safe laser practices, requirements and written SOPs.
* Operate lasers/laser systems only under the conditions authorized by the PI.
* Promptly report all unsafe conditions, known or suspected incidents to the PI.

**Laser Users**

* Complete the Laser User Checklist (refer to Appendix A - Laser User Checklist and Registration Form).
* Participate in the University’s medical surveillance program, as directed by the LSO.
* Complete York’s Laser Safety Training course prior to working with lasers.
* Be familiar with the general operating procedures and specific safety hazards of lasers under their control. Wear the appropriate personal protective equipment (PPE) including lab coat, gloves, and safety glasses as applicable and as required.
* Work as directed by their laser supervisors, in compliance with the *Occupational Health and Safety Act* and the Laser Safety Program.
* Operate Class 3B and Class 4 laser/laser systems safety and in a manner consistent with safe laser practices, requirements and written SOPs.
* Operate lasers/laser systems only under the conditions authorized by the PI.
* Refrain from operating equipment or working in a way that may pose a risk to the health and safety of others working in the laboratory.
* Report known or suspected incidents or safety violations to their laser supervisors.

**Laser Laboratory Workers**

* Participate in the Laser Safety Awareness Training on YU Learn prior to working inside the nominal hazard zone (NHZ).
* Report to the laser supervisor/PI any medical conditions that could cause them to be at increased risk for chronic exposure, e.g. photosensitivity of the skin, use of photosensitizing medications, and dermatological abnormalities of the skin.
* Participate in the University’s medical surveillance program, as directed by the LSO.
* Work as directed by their laser supervisors, in compliance with the *Occupational Health and Safety Act* and the Laser Safety Program.
* Report any concerns or unsafe conditions to the laser supervisor/PI.
* Promptly report known or suspected incidents to the laser supervisor/PI.

**Laser Safety Sub-committee (LSS)**

Consists of faculty, staff and/or student members who function as a peer review committee and are selected from departments where lasers are used. An advisory committee at York University that reports to the Radiation Safety Committee.

* Administer matters relevant to laser safety and is the ultimate reviewing and authorizing agent for the use of lasers on campus;
* Ensure that criteria for the safe use of lasers are established for users in the University in accordance with the requirements of the Ontario Ministry of Labour, Immigration, Training and Skills Development and related regulations;
* Recommend a level of resources sufficient to meet the requirements of the Laser Safety Program;
* Receive reports from the LSO on laser safety and recommends remedial action to correct any deficiencies;
* Suspend, restrict or terminate any unsafe operation of lasers or laser systems; and
* Participate in the review the Laser Safety Program once every 3 years.

**Laser Safety Officer (LSO)/Alternate LSO**

A specially trained member of Health, Safety and Employee Well-Being.

* Provide advice and consultation on the safe operation of lasers including verification of Standard Operating Procedures and prescribed controls are in effect
* Assist laser users in complying with related legislation.
* Participate in the commission/decommission of Class 3B and Class 4 lasers/laser systems; and
* Responsible for issuing laser permits to PIs;
* Evaluate and make recommendations for control of laser hazards, including establishment of the NHZ.
* Administer eye examination for laser users and laser laboratory workers as needed.
* Provide or coordinate laser safety training for laser users and laser laboratory workers.
* Recommend protective equipment such as eyewear
* Conduct safety audits of laser laboratories as required.
* Authorized to inspect all areas of York University’s operations and activities related to laser/laser systems.
* Ensure appropriate laser working area signs and equipment labels are in place and in accordance with code of practice;
* Ensure safe operation through the authority to suspend, restrict or terminate operations; stopping individual/laboratory work when the safety of workers, the public or the environment is at risk; documenting the technical reasons for the above decision and reporting to the LSS.
* Report to the Radiation Safety Committee on lasers or laser systems that do not meet this program’s requirements.
* Investigate laser-related incidents, analysis of causes, ensuring corrective actions are taken as required.

**Health, Safety and Employee Well-Being (HSEWB)**

* Coordinate the development and review of the Laser Safety Program.
* Maintain an inventory of all Class 3B and Class 4 lasers. This includes classifying or verifying classification if necessary.
* Maintain training, medical surveillance, inspection or related records as required.
* Assign a laser safety officer (LSO) and an alternate.
* Ensure the LSO and alternate LSO complete appropriate level of training (e.g., Laser Safety Officer Training)
* Liaise with external government agencies, where required.

**Joint Health and Safety Committee(s)**

* Support employees with health and safety concerns in the workplace; and
* Participate in the review of this program.

**Union(s)**

* Provide representation to workers in accordance with the applicable collective agreement and legislative requirements; and
* Participate in the review of this program through the Joint Health and Safety Committees.

# 6.0 Part A: Prevention and Education

## 6.1 Identifying the hazard

Exposure to laser radiation can produce eye and skin damage. The extent of the damage depends on the wavelength and intensity of the radiation, and on the duration of exposure. Powerful lasers may also present fire and chemical hazards. Refer to Appendix C for additional information on hazards, laser components, characteristics, and classification.

Safety inspections are used identify hazards in the workplace. Laser safety inspections are arranged by the LSO and conducted in conjunction with the PI, laser supervisor, and/or a member of the LSS inspection team. Refer to section 8.3 on laser safety inspections and Appendix B for the laser safety inspection form.

## 6.2 Assessing the risk

A hazard evaluation of the laser being used is required for the purpose of classifying the laser and to determine the types of precautionary measures required. Hazard evaluations are arranged by the LSO and conducted in conjunction with the PI or laser supervisor. Refer to Appendix D for terms and conditions that should be determined for Class 3B and 4 lasers for the purpose of hazard evaluation.

## 6.3 Controlling the risk

Where it is not possible to eliminate an identified hazard, control measures are to be implemented to mitigate the risk of illness or injury. When determining the type of control to implement, the following factors should be considered:

* The cause, nature, and extent of the hazard;
* The hierarchy of preventive and protective measures (i.e., elimination, substitution, engineering, and administrative measures);
* Applicable legal requirements;
* Applicable standards, codes, guidelines, and best practices;
* Availability of suitable technology; and
* Opportunities to improve the design of work systems.

The hierarchy of controls can be applied to spaces utilizing lasers:

Engineering Controls

Appropriate control measures are devised to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and to other hazards associated with the operation of laser/laser systems during operation and maintenance.

Commercial laser products will be certified by the manufacturer and will incorporate some engineering controls. Additional controls may be required in order to reduce the potential for hazard associated with some applications of lasers and laser systems. Refer to Appendix E for Engineering Control Measures for the Four Classes.

In some circumstances, such as research and development, some of these controls may be impracticable. In such cases, a hazard evaluation, in conjunction with the LSO, shall be conducted to ensure control measures are instituted to assure safe operation.

Administrative and Procedural Controls

Administrative and procedural controls are methods or instructions which specify rules, or work practices, or both, which implement or supplement engineering controls and which may specify the use of personal protective equipment. Refer to Appendix F for administrative and procedure controls for the four classes which is consistent with ANSI requirements for laser systems.

Eye Protection

Within the NHZ, eye protection (e.g. goggles, face shields, prescription eyewear using special filter or coating) is required and its use is to be enforced by the supervisor when engineering controls may fail to eliminate potential exposure in excess of the applicable MPE. It is important to select eye protection specifically for the wavelength and power of the particular laser.

The amount of attenuation offered by the eye protection is measured by OPTICAL DENSITY (OD). The OD is given by the equation:

 OD = log (i /t) where i is the incident power on the eye protector

t is the power transmitted through the eye protector

Since the power transmitted must not exceed the MPE,

OD = log (Eo /MPE) where Eo is the power of a laser beam (through the appropriate aperture) before it strikes the eye protector, expressed as W/cm2 or J/cm2.

Therefore, the greater the OD, the greater the attenuation (less light will reach the eye).

Laser Protective Eyewear Requirements

1. Laser protective eyewear is to be available and worn by all personnel within the NHZ of Class 3B and Class 4 lasers where exposures above the MPE can occur.
2. All laser protective eyewear shall be clearly labelled. The associated wavelength dependent transmissive properties of the eyewear must be available to the user.
3. Laser protective eyewear shall be inspected for damage periodically and prior to use.

Refer to Appendix E and Appendix F for additional information about control measures for laser safety.

## 6.4 Evaluating Implemented Control Measures

To confirm that the controls are effective, and hazards are eliminated or minimized, several methods can be utilized which include, but are not limited to:

* Physical inspections
* Observations
* Incident investigation reports
* Analysis of injury and illness trends
* Employee feedback

## 6.5 Training and education

Education and training is required for laser users, laser laboratory workers, laser supervisors, and PIs prior to the commencement of work. The level of training shall be commensurate with the level of potential hazard. Refresher training is required once every three years if personnel continue to use or work with or around lasers.

### Laser Users

Required to complete the following prior to start of laser work:

* Review the **Laser Safety Program**.
* Complete the “**Laser User Checklist**” (see Appendix A).
* **Laser Safety Training and written test** offered by HSEWB. The Laser Safety Training covers the following topics:
	+ Laser fundamentals;
	+ Bioeffects of laser radiation on the eye and skin;
	+ Relations of specular and diffuse reflections;
	+ Non-radiation hazards (electrical, chemical etc.);
	+ Laser classifications;
	+ Control measures: protective equipment, signage etc.;
	+ Overall management and employee responsibilities;
	+ Quiz; and
	+ Laser eye exam (as directed by LSO)

Where contact with or usage of high voltage power supplies are involved, training shall include cardiopulmonary resuscitation (CPR) and electrical safety. Refer to the [York University’s First Aid Program](https://yulink-new.yorku.ca/documents/20182/1360664/First%2BAid%2BProgram/b1ac5adb-1d09-4985-bb0b-ec0155717dde) via YU link for details on how to obtain CPR training.

In addition to the above, all laser users will have on the job training provided by the Principal Investigator that will include the following parts:

* General awareness of the hazards in laser laboratories or other areas where lasers are used.
* Be familiar with all standard operating procedures and specific safety hazards of the Class 3B and Class 4 laser/laser systems that they will operate/oversee.
* A PI or laser supervisor will demonstrate the safe use of a laser to the new user.
* The new user will operate the laser in the presence of the PI or laser supervisor.
* The PI or laser supervisor will evaluate the practical knowledge of the new user and will determine when to allow the new user to work without supervision.

### Laser Laboratory Workers

* Review the **Laser Safety Program**.
* Complete the “**Laser User Checklist**” (see Appendix A).
* **Laser Safety Awareness Training and written test** offered by HSEWB. Laser laboratory workers must complete this training prior to working in the vicinity of Class 3B or Class 4 laser/laser systems. The Laser Safety Awareness Training covers the following topics:
	+ Laser classification;
	+ Laser beam and non-beam hazards;
	+ Laser hazard controls;
	+ Laser incidents and emergency preparedness;
	+ Quiz; and
	+ Laser eye exam (as directed by LSO)

Laser laboratory workers are not trained to use the lasers or to give advice on laser use.

### Laser Supervisors

* Review the **Laser Safety Program**.
* Complete the “**Laser Registration Form**” if not completed previously by the Principal Investigator (see 7.1 - Registration of Lasers and Laser Inventory section below)
* Complete the same training requirements as *Laser Users* identified above.

### Principal Investigators (PI)

* Review the **Laser Safety Program**.
* Complete the “**Laser Registration Form**” for all lasers that are Class 3B and 4 (see 7.1 - Registration of Lasers and Laser Inventory section below)
* Complete the same training requirements as *Laser Users* identified above.

# 7.0 Part B: Procedures and Processes

## 7.1 Registration of lasers and laser inventory

All Class 3B and Class 4 lasers shall be registered with the LSO by the completion of the registration form (Appendix G). PIs are responsible for completing the registration form and sharing it with the LSO for all Class 3B and Class 4 lasers in their possession so that they can be added to the University’s inventory.

The LSO shall maintain a laser inventory for all Class 3B and Class 4 lasers at York University in accordance with the Ontario Ministry of Labour requirements. The inventory, at a minimum, should include the following information: name and phone number of owner, location of laser, laser type (CO2, Nd:YAG, etc.) and the number of lasers.

The LSO will send the laser inventory to PIs for review and update on an annual basis.

## 7.2 Laser permits

*Issuing Permits*

PIs who have charge of a laser laboratory and/or Principal authority for Class 3B or Class 4 laser/laser systems must apply for a laser safety permit. Complete Appendix G. A permit will be issued by the LSO and posted in the laser lab (Appendix H). Laser safety permits are valid for three years and can be revised as needed.

*Revoking permits*

The LSO or any member of the LSS lab inspection team has the authority to initiate the procedure for revoking a permit when there is an actual or perceived threat to health, safety or security involving use of lasers.

Procedure:

1. On the occurrence which may include minor infractions which have been noted numerous times in the inspections, the permit holder will be notified in writing (e.g. memo) by the LSO or LSS of the infractions or violations that were noted. The permit holder will be informed that a follow-up visit will be conducted by the LSO and/or LSS lab inspection team to review compliance and the consequence, should a re-occurrence happen within one year.
2. On the second occurrence (within one year), the case is escalated to the University Radiation Safety Officer who will send a letter to the permit holder, with a copy to the Department Chair and the Dean, outlining the infractions, the responsibilities of the permit holder in that respect and the consequences of further infractions. The permit holder will be informed that a follow-up visit will be conducted by the LSO and/or LSS lab inspection team to review compliance.
3. On the third occurrence (within one year), the permit will be revoked. All laser systems under the permit will be suspended.

Notes:

* Any violations greater than one year old will not be considered in further actions.
* The LSO or LSS lab inspection team reserves the right to escalate the occurrence to the Radiation Safety Officer if a serious, immediate risk to health, safety or security violation occurs.

*Reinstatement of Permit*

In order for a revoked permit to be reinstated, the permit holder must re-apply for another permit.

## 7.3 Commissioning and decommissioning of Class 3B and Class 4 lasers

### Commissioning Procedures

The LSO will commission a room which lasers with Class 3B and 4 open beams are used. The following will be checked:

Class 3B

1. Class 3B laser sign on all entrances to the room.
2. The laser beam is enclosed as much as possible.
3. The laser and the optics are fixed on the table.
4. The laser beam does not leave the optical table. All laser beams and stray beams are terminated with a stop.
5. Laser direct beam or specular reflections are not directed towards the entrances. If this is necessary, the entrance must be protected with a curtain/barrier.
6. Laser beam must not be directed toward windows. If this is necessary, the windows must be covered.
7. The laser beam is not at eye level.

Class 4

1. Class 4 laser sign on all entrances to the room.
2. All entrances to the room must:
3. Have interlocks (defeatable or non-defeatable) connected with the laser power to shut down the laser or to a shutter to block the beam, or
4. A blocking barrier/curtain and a laser warning light that indicates when the laser is operating.
5. All entry ways must allow both rapid entrance and exit to the laser controlled area under any conditions.
6. All windows are covered.
7. The laser beam is enclosed as much as possible.
8. The laser and the optics are fixed on the table.
9. The laser beam does not leave the optical table. All laser beams and stray beams are terminated with a stop.
10. Flammable materials are kept out of the laser beam.
11. The emergency "Panic Button" (switch or equivalent device) is available and in good working condition.

Rooms in which Class 3B or Class 4 lasers are used with fiber optics

If the beam is totally enclosed in the fiber and the sample, no further requirements are necessary. If the laser beam can, at any time, exit the fiber in free space, the LSO will determine the NHZ for the laser and the particular fiber used. The area within which the irradiance is above the maximum permissible exposure (MPE) must be enclosed by curtains/barriers/screens, access must be controlled. Inside this area only authorized trained personnel, wearing the protective eyewear must be allowed. If the area is extended to the whole room, controls for the applicable laser class (see above) must be implemented.

### Decommissioning Procedures

All class 3B and 4 lasers must be decommissioned at the end of their use. The following steps must be followed:

1. The laser must be made inoperative by removing/destroying mirrors from the optical cavity.
2. For lasers with toxic active medium (toxic gases or dyes), the laser active medium must be removed, and the optical cavity cleaned.
3. All toxic materials must be disposed off according to the applicable regulations. Contact the LSO for additional guidance.
4. All laser signs must be removed.
5. The electrical power supply must be disposed of as any other electrical equipment.

## 7.4 Laser safety inspections

PIs will conduct laser safety inspections at least on an annual basis. Inspections include checking signage in laboratories and on lasers, the existence of written operating procedures, eye protection, beam enclosures and interlocks on protective housing, etc. Refer to Appendix B for laser safety inspection form. LSOs will conduct audits on a random basis and will provide at least a week’s advance notice to the PIs. Audit may consist of, but not limited to, the following:

* Review of inspection records of Class 3B and Class 4 laser facilities.
* Review of training records to confirm all laser users have valid and appropriate training.

## 7.5 Medical assessment

Medical assessments (eye examinations) are required for laser users prior to using Class 3B and 4 lasers and after completion of Laser Safety Training. Eye examinations are performed as part of the Laser Safety Training and prior to working with or around lasers.

The eye examination may be conducted to establish the baseline of ocular conditions prior to exposure to laser radiation. This examination will also allow for the early detection of any signs of damage and/or injury, thereby facilitating early treatment.

*Types of Eye Examination*

The examination can be scheduled with HSEWB or directly with the LSO or alternate LSO. The baseline examination protocol includes the following tests:

1. Visual Acuity
2. Macular Function
3. Colour Vision
4. Amsler Grid (to assess blind spots and distortions)

Where all the responses are normal, no further examination is required. For individuals whose ocular function in any of the above (a to d) test is not normal, or with significant eye problems or who are functionally one-eyed or both, referral will be made to a medical professional for further examination. Individuals must be cleared by HSEWB before allowed to use lasers or work within the vicinity of the laser.

Periodic eye examinations are not required by this program unless required as a result of medical status, ocular illness or injury.

## 7.6 Suspected or known laser injury

Any employee with suspected laser eye damage must contact HSEWB and medical professional.

Reportable incidents are those that:

* Result in personal injury (including first aid) or property damage; or
* Have the potential to result in significant personal injury or property damage even though no injury or damage actually occurred; and
* Occur to any person on York University property; or
* Occur to any York University employee during the course of their work.

The Principal Investigator is responsible to report all incidents involving Class 3B and Class 4 laser/laser systems according to [York University’s Incident Investigation Program](https://yulink-new.yorku.ca/documents/20182/92034/Accident%2BInvestigation/6b6a91fa-0445-49a6-9592-d189ad4282c6) via YU Link.

# 8.0 Reprisal

This program prohibits reprisals against employees who exercise their rights or bring forward concerns pertaining to their health and safety. Employees who engage in reprisals or threats of reprisals may be disciplined up to and including termination from employment.

Reprisal includes:

* Any act of retaliation that occurs because an employee has complained or provided information about an incident or concern;
* Intentionally pressuring a person to ignore or not report an incident or concern; and
* Intentionally pressuring a person to lie or provide less than full cooperation with an investigation.

# 9.0 Non-Compliance

Any employee who violates this program, and/or Principal Investigator / laser supervisor who fails to take action when advised of a violation, will be subject to appropriate disciplinary action, up to and including termination of employment.

Disciplinary action will also be taking if a complaint is found to have been made fraudulently and with malicious intent.

# 10.0 Record Keeping

HSEWB is the Office of Primary Responsibility for keeping records related to tests of employees to comply with health and safety legislation and standards, which includes personal and medical records.

Laser safety training records are retained in YU Learn.

PIs are required to keep record of the latest permit issued and all documented inspections.

Permits and checklists submitted to HSEWB will be retained in accordance with the University’s record retention requirements. Copies can also be retained in the department / faculty files.

# 11.0 Reviewed By

The York University Laser Safety Program shall be reviewed once every three years in consultation with applicable Joint Health and Safety Committees and area Health and Safety Officers.

This program was also reviewed by the following parties/areas:

* Radiation Safety Committee
* Laser Safety Sub-committee

# 12.0 Related Policies / Programs / Procedures

[Incident Investigation Program](https://yulink-new.yorku.ca/documents/20182/92034/Accident%2BInvestigation/6b6a91fa-0445-49a6-9592-d189ad4282c6)

[First Aid Program](https://yulink-new.yorku.ca/documents/20182/1360664/First%2BAid%2BProgram/b1ac5adb-1d09-4985-bb0b-ec0155717dde)

[Hazard Recognition and Reporting Program](https://yulink-new.yorku.ca/documents/20182/1360664/Hazard%2BRecognition%2Band%2BReporting%2BProgram/f8bc5ecd-08d2-4079-a0d7-0e953214a3b6)

[Laboratory Safety Program](https://yulink-new.yorku.ca/documents/20182/29507656/Laboratory%2BSafety%2BProgram/388ec4d8-728d-4f64-ae87-e96d6ceaac14)

# References

1. Laser Institute of America (2022). ANSI Z136.1-2022: American National Standard for Safe Use of Lasers.
2. Ministry of Labour, Immigration, Training and Skills Development (2021). Laser Safety in the Workplace. <https://www.ontario.ca/page/laser-safety-workplace#section-5>

# Appendix A: Laser User Checklist

I, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(print name), agree to abide by the requirements established for Laser users as stated in the York University Laser Safety Program.

The following requirements have been completed:

[ ]  I have completed the **Laser Safety Training** offered by Health, Safety and Employee Well-Being on YU Learn.

[ ]  I have completed the **medical assessment** (i.e. eye examination) with Health, Safety and Employee Well-Being (email the LSO/Alternate LSO/HSEWB at hsewb@yorku.ca).

[ ]  I have read the most recent **Laser Safety Program** offered by York University.

[ ]  I have reviewed **written Standard Operation Procedures** (SOP) for the particular laser(s) that I will be working with. The SOP contains the Nominal Hazard Zone (NHZ) and the type of Personal Protective Equipment required.

My laser supervisor/Principal Investigator is: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Completion date (MM/DD/YYYY): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Laser user signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Student/Employee #:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Send completed form to**: Health, Safety and Employee Well-Being

 hsewb@yorku.ca

# Appendix B: Laser Safety Inspection Form

*Complete a form for each laser.*

|  |  |  |  |
| --- | --- | --- | --- |
| PI Name: |  | Permit Number: |  |
| Laser Location: |  |
| Laser Type: |  | Laser Class: |  |
| Model: |  | Serial # |  |
| Inspector Name: |  | Date of Inspection: |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Control Measures** | **YES**  | **No** | **N/A** | **Comments** |
| 1. **LASER POSTING, LABELLING, ROOM SECURITY**
 |
| Entrances – warning sign posted (laser status indicator for Class 4) |  |  |  |  |
| Room security adequate (e.g. only authorized access) |  |  |  |  |
| Windows/doors covered (Class 4) |  |  |  |  |
| Entryway interlock system  |  |  |  |  |
| Interlock functioning |  |  |  |  |
| A door, blocking barrier, curtain, etc. at entryway |  |  |  |  |
| 1. **LASER UNIT SAFETY CONTROL MEASURES**
 |
| **Protective housing** |  |  |  |  |
| Interlocks on protective housing present and functioning |  |  |  |  |
| Beam shutter present |  |  |  |  |
| Key control (Class 3B & 4) |  |  |  |  |
| Laser activation warning system (with emission delay) in place |  |  |  |  |
| Remote interlock connector (emergency shutoff) available and functioning |  |  |  |  |
| 1. **ENGINEERING SAFETY CONTROL MEASURES**
 |
| Laser and optics secured to table |  |  |  |  |
| Open beam path enclosed/ controls in place to block |  |  |  |  |
| 1. **ENGINEERING SAFETY CONTROL MEASURES** (continued)
 |
| Beam barriers in place |  |  |  |  |
| Emergency beam stop or attenuator (Class 2, 3 & 4) in place |  |  |  |  |
| Beam intensity reduced through filtration |  |  |  |  |
| Remote viewing of beam |  |  |  |  |
| Reflective materials kept out of beam path |  |  |  |  |
| Stray beams are controlled |  |  |  |  |
| 1. **ADMINISTRATIVE AND PROCEDURAL SAFETY CONTROL MEASURES**
 |
| SOP (Class 4 include alignment protocol) available |  |  |  |  |
| Laser users/lab workers/supervisors all trained and valid |  |  |  |  |
| Laser permit posted and up to date |  |  |  |  |
| Operated by authorized personnel |  |  |  |  |
| Eye protection available/used (N/A if fully enclosed) |  |  |  |  |
| Proper skin protection available |  |  |  |  |
| Room egress – accessible |  |  |  |  |
| Service access panel – tooled and labelled |  |  |  |  |
| 1. **ACTION REPLY**
 |
| Corrective measures taken: |  |
| Date of completion: |  |
| Name: |  | Signature: |  |

**PLEASE COMPLETE SECTION E and RETURN COMPLETED FORM TO:** Health, Safety and Employee Well-Being,

hsewb@yorku.ca

Distribution: Laser Safety Officer, Permit holder

# Appendix C: Laser Components, Classification and Hazards

## Laser Components

All lasers contain three primary sections (see figure 1 below):

1. Active Medium

The active medium contains atoms, molecules or ions whose electrons may be excited to a metastable energy level by an energy source to produce laser light. The active medium can be either solid crystalline materials such as ruby, or solutions of organic dyes, or gases such as Helium/Neon, or semiconductors such as Gallium/Aluminium/Arsenic. The material determines many of the laser beam’s output characteristics, including its wavelength.

 There are four major types of lasers based on the lasing medium:

* Solid State Lasers
	+ e.g. ruby laser, Nd:YAG (Neodymium:Yttrium/Aluminum/Garnet)
* Semiconductor or Diode Lasers
	+ e.g. GaAlAs (Gallium/Arsenic/Arsenic)
* Liquid (Dye solution) Lasers
* Gas Lasers
	+ e.g. Carbon dioxide, rare gas-halogen, nitrogen
1. Excitation Mechanism

The excitation mechanism is determined by the input energy device which pumps energy into the active medium. This mechanism can be optical, electrical or chemical.

1. Optical Resonator

The optical resonator consists of two specially designed mirrors. The high reflectance mirror reflects essentially 100% of the light hitting it while the other partially transmissive mirror (called the output coupler) reflects less than 100% of the light hitting it and transmits the remainder.

**Figure 1 - Laser Components**

Active Medium

High Reflectance Mirror

Output Coupler Mirror

Output Beam

Excitation Mechanism

## Laser Characteristics

Laser light is monochromatic, directional and coherent. Monochromatic means that all the light produced by the laser is of one wavelength. Directional means that the beam from the laser does not diverge as quickly as other light. Coherent means that all the waves of light are generated in phase with each other.

## Classification of Lasers

All lasers are classified by the manufacturer and labelled with the appropriate warning labels. Any modification of an existing laser or an unclassified laser must be classified by the Laser Safety Officer (LSO) prior to use.

The following criteria are used to classify lasers:

1. Wavelength or wavelength range.
2. For continuous wave (CW) or repetitively pulsed lasers: average power output (Watts) and limiting exposure duration inherent in the design are considered.
3. For pulsed lasers: total energy (J) per pulse (or peak power), pulse duration, pulse repetition frequency, and the emergent beam radiant exposure (J/cm2).
4. For extended source lasers or laser systems (e.g. laser arrays, laser diodes, and lasers having a permanent diffuser within the output optics): in addition to the parameters listed above, the maximum angle subtended must be known, and the source radiance or integrated radiance may be needed.

Below is a brief summary of laser classification. For detailed classification, refer to ANSI Z136.1-2022.

***Class 1 Lasers (Exempt)***

Lasers that are not hazardous for continuous viewing or are designed in such a way that human access to laser radiation is prevented. They are low power lasers or high power embedded lasers (e.g. laser printers, CD ROM devices).

***Class 1M Lasers (Exempt with Restrictions)***

Lasers that are not hazardous for continuous viewing with an unaided eye, however, may be hazardous when viewing with the aid of an optical instrument. These lasers are exempt from control measures unless:

* Optically aided viewing of the beam is expected, and/or
* Unattended operation in areas where the general public is present.

These types of lasers create large-diameter beams (e.g. LED) or beams that are divergent. If a beam from a Class 1M laser is refocused, the hazard class of the laser may differ and increase.

***Class 2 Lasers (Low Power)***

These lasers produce visible (wavelength: 400 to 700 nm) radiation, CW beams, with power up to 1 mW. They do not normally present a hazard from momentary exposure (less than 0.25 seconds) due to the normal human aversion responses, but would if viewed directly for extended periods of time (more than 0.25 seconds).

***Class 2M Lasers (Low Power with Restrictions)***

These lasers produce visible (wavelength: 400 to 700 nm) radiation, CW beams, with power up to 1 mW. They do not normally present a hazard from momentary exposure (less than 0.25 seconds) due to the normal human aversion responses, but would if viewed directly for extended periods of time (more than 0.25 seconds) or with the aid of an optical instrument.

***Class 3R Lasers (Medium-Power)***

All Class 3 lasers which have an accessible output power between 1 and 5 times Class 1 lasers for wavelengths in the non-visible spectrum (less than 400 nm or greater than 700 nm), or 5 times (5 mW) the Class 2 lasers for wavelengths between 400 nm and 700 nm (visible spectrum), are Class 3R. These lasers generally do not cause permanent damage. These lasers would present a hazard if viewed using collecting optics (fibre optics loupe or telescope), or if the laser is viewed directly for extended periods of time. The normal human aversion responses will protect from this class of laser, however, individuals may experience temporary “flash blindness”. These lasers will not pose a fire or a diffuse-reflection hazard.

***Class 3B Lasers (Medium-Power)***

Lasers that produce acute eye hazards from momentary intrabeam viewing or specular (mirror-like) reflections. Class 3B lasers do not typically produce a hazardous diffuse reflection except when higher powered or viewed at close proximity. Class 3B lasers do not normally pose a fire or skin hazard, but would present a hazard if using collecting optics (fibre optics loupe or telescope). All Class 3 lasers and laser systems, which do not meet the requirements for Class 3R, shall be classified as Class 3B. For example, the limits for CW lasers are between the Class 3R limits and 500 mW. Class 3B laser system requires the approval of appropriate control measures by the LSO to reduce the risk of a hazardous exposure to the eye from a direct or specularly reflected beam.

***Class 4 Lasers (High Power)***

Lasers that can damage the skin as well as the eye during momentary intrabeam exposure or exposure to specular and diffuse reflection. In addition, such lasers can ignite combustible materials. Lasers exceeding 500mW.

## Lazer Hazards

Exposure to laser radiation can produce eye and skin damage. The extent of the damage depends on the wavelength and intensity of the radiation, and on the duration of exposure. Powerful lasers may also present fire and chemical hazards.

***Effects on the Eyes***

Exposure of the eyes to laser radiation above the MPE is hazardous and must be avoided. The potential for injury to the different structures of the eye (Figure 2) depends upon which structure absorbs the energy. Laser radiation may damage the cornea, lens or retina depending on the wavelength, intensity of the radiation and the absorption characteristics of different eye tissues.

**Figure 2 - Structures of the Eye**



Below are the effects of optical radiation at various wavelengths on various structures of the eye (Table 1).

**Table 1 - *Wavelengths and absorption of various wavelengths of light by the human eye***

|  |  |
| --- | --- |
| *Visible and near-infrared wavelengths, 400 to 1400 nm*Radiation is transmitted through the ocular media with little loss of intensity and is focused on the retina. Laser radiation in this range is termed the *retinal hazard region*. The focusing effects of the cornea and lens will increase the irradiance on the retina by up to 100,000 times.  |  |
| *Middle, far-infrared (1400 nm to 1 mm) and Middle Ultraviolet (180 nm to 315 nm)*The surface of the cornea absorbs radiation at these wavelengths. The absorption of middle ultraviolet radiation by the cornea produces photokeratitis (welders flash) by a photochemical process. For middle and far-infrared radiation, damage to the cornea results from the absorption of energy by tears and tissue water causing a temperature rise. Middle- infrared radiation penetrates deeper and may lead to the development of cataracts. |  |
| *Near-ultraviolet (315 nm to 400 nm, UV-A)*Radiation at the near-ultraviolet is absorbed in the lens and may contribute to certain forms of cataracts. |  |

***Effects on the Skin***

Skin effects are usually considered of secondary importance, however, with the more widespread use of lasers emitting in the ultraviolet spectral region, as well as higher power lasers, skin effects have assumed greater importance.

Erythema (sunburn), skin cancer and accelerated skin aging are possible in the 230 to 380 nm wavelength range. The most severe effects occur in the UV-B range (280 to 315 nm). Increased pigmentation can result from chronic exposures in the 280 to 400 nm range. In addition, photosensitive reactions are possible in the 310 to 600 nm wavelength regions. The bioeffects in the infrared range (700 to 1000 nm) will be skin burns and excessive dry skin.

***Other Associated Hazards***

Electrical Hazards

* Both pulsed and CW lasers may have high voltage and high current power supplies, and pulsed lasers utilize capacitor banks. Some gas lasers have radio-frequency power supply circuits.
* Improper grounding or shielding, or failure to follow standard electrical safety procedures during maintenance and service may result in electrical shock, burns or blistering, or electrocution. For example, since static electricity can be built up when some solvents flow through plastic tubing, grounding wire should be installed inside the tubing.

Chemical Hazards

* Many dyes used as lasing medium are toxic, carcinogenic, mutagenic or corrosive. Exposure to dyes during solution preparation should be minimized. Safety information regarding the dye can be obtained by reading the appropriate Safety Data Sheet.
* Special Optical materials used for far infrared windows and lenses have been the source of potentially hazardous levels of airborne contaminants. For example, calcium telluride and zinc telluride will burn in the presence of oxygen when beam irradiance limits are exceeded. Exposure to cadmium oxide, tellurium, and tellurium hexafluoride should also be controlled.
* Solvents used for mixing the dye may be flammable and/or toxic (e.g. irritants, narcotics, or anaesthetics). A low dye concentration may mean solvents are of the greater concern.
* Cryogenic fluids, such as liquid nitrogen, helium and hydrogen, are used in cooling systems of certain lasers. Skin and eye contact with such materials could cause frostbite.
* Compressed gases used in some lasers can be hazardous. For example, chlorine gas is corrosive; helium and argon are asphyxiant (displaces oxygen); and hydrogen is a flammable gas. There is also the hazard of unsecured cylinders: if a cylinder should have its valve broken off in a fall, it becomes an uncontrolled missile.

Fire Hazards

* Class 4 lasers represent a fire hazard. Depending on construction material, beam enclosures, barriers, stops and wiring are all potentially flammable if exposed to high beam irradiance for more than a few seconds.
* Flammable solvents, if used in an enclosed area without adequate dilution or exhaust ventilation, pose a fire or explosion hazard in the presence of an ignition source.

Explosion Hazards

* Explosion hazards may exist if high pressure arc lamps, filament lamps or capacitor banks fail during operation. These components should be enclosed in a housing which will withstand the maximum explosive force that may be produced.
* Laser targets and some optical components may also shatter if heat cannot be dissipated quickly enough. Consequently, care must be used to provide adequate mechanical shielding when exposing brittle materials to high intensity lasers.

Collateral Radiation

* X-rays can be generated from high voltage (over 15 kV) power supply tubes. Exposure to X-rays may cause tissue damage, leukemia or other cancers, or permanent genetic effects.
* UV and visible radiation may be generated from some laser discharge tubes and pumping lamps. The levels produced may exceed the Maximum Permissible Exposure and thus cause skin and eye damage.
* Plasma radiation may be emitted from interactions between very high powered laser beams and target materials (e.g. in laser welding). The plasma generated may contain hazardous UV emissions.
* Radio frequency (RF) is emitted from some pumping systems. Q switches and plasma tubes are RF excited components.

# Appendix D: Hazard Evaluation

Below are some terms and conditions that should be determined for Class 3B and 4 lasers for the purpose of hazard evaluation (see ANSI Z136.1-2022 for details):

**Table 2 - Viewing Conditions**: intrabeam or from specular reflections versus diffuse reflection

|  |  |
| --- | --- |
| *Intrabeam viewing* refers to viewing the direct (primary) beam or beam reflected off smooth surface. This type of viewing is most hazardous. | Laser |
| *Specular reflection* is mirror-like reflections and can reflect close to 100% of the incident light. Intrabeam viewing of a specularly reflected (secondary) beam from a flat surface reflector. Specular reflections are most hazardous when the reflecting surface is flat.  | Laser  |
| *Diffuse Reflections* (extended source) result when surface irregularities scatter light in all directions. Extended source viewing produces a larger retinal image. | Laser |

MPE - Maximum Permissible Exposure (J/cm2 or W/cm2(for irradiance))

The MPE is defined in ANSI Z136.1-2022 as “The level of laser radiation to which an unprotected person may be exposed without adverse biological changes in the eye or skin”. The MPE is not an exact limit between safe and hazardous exposures; rather it is a maximum level which various experts agree should be occupationally safe for non-photosensitive individuals for repeated exposures. The biological effects of laser radiation are dependent on the wavelength of the laser, exposure duration and power intensity. Therefore MPE’s are calculated using correction factors for these indices. The MPE has been expressed (normalized) relative to the limiting aperture area. Calculations of MPE’s if required can be done with the assistance of the LSO for Class 3B and Class 4 lasers.

Nominal Hazard Zone (NHZ)

Where unenclosed beams are required, a NHZ needs to be defined so as to determine an area in which control measures are required. The NHZ is the space or distance within which the level of direct, reflected or scattered laser light exceeds the MPE level for the laser.

# Appendix E: Engineering Control Measures for Four Classes

|  |  |
| --- | --- |
| **Control Measures** | **Classification** |
| **ENGINEERING CONTROLS** | **1** | **1M** | **2** | **2M** | **3R** | **3B** | **4** |
| Protective Housing | X | X | X |  | X | X | X |
| Without Protective Housing | - | - | - | - | - | X | X |
| Interlocks on Protective Housing | ê | ê | ê | ê | ê | X | X |
| Service Access Panel | ê | ê | ê | ê | ê | X | X |
| Key Control | - | - | - | - | - | ▪ | ▪ |
| Viewing Portals | Ensure viewing limited to < MPE |
| Facility Window Protection | - | - | - | - | - | X | X |
| Laser Protective Barriers and Curtains | - | - | - | - | - | X | X |
| Collecting Optics | X | X | X | X | X | X | X |
| Fully Open Beam Path | - | - | - | - | - | XNHZ | XNHZ |
| Limited Open Beam Path | - | - | - | - | - | XNHZ | XNHZ |
| Enclosed Beam Path | None required if protective housing in place, and the housing is equipped with interlocks. |
| Area Warning Device | - | - | - | - | - | ▪ | X |
| Laser Radiation Emisison Warning | - | - | - | - | - | ▪ | X |
| Class 4 Laser Controlled Area | - | - | - | - | - | - | X |
| Entryway Controls | - | - | - | - | - | - | X |
| Remote Interlock Connector | - | - | - | - | - | ▪ | X |
| Beam Stop or Attenuator | - | - | - | - | - | ▪ | X |
| Activation Warning Systems | - | - | - | - | - | ▪ | X |
| Emission Delay | - | - | - | - | - | - | X |
| Remote Firing and Monitoring | - | - | - | - | - | - | ▪ |
| Labels | X | X | X | X | X | X | X |
| Area Posting | - | - | - | - | ▪ | XNHZ | XNHZ |

Legend

**X** Shall ▪ Should

**-** No requirement ê Shall if enclosed Class 3B or Class 4

**MPE** Shall if MPE is exceeded **NHZ** Nominal Hazard Zone analysis required

\* See following pages for details

## Engineering Controls

***Protective Housing***

A protective housing is a physical barrier preventing laser radiation in excess of the MPE from exiting the laser. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing limits access to other associated radiant energy emissions and electrical hazards. Normally, this protective housing is provided by the manufacturer.

***Laser Use without Protective Housing***

In some circumstances (e.g. research and development and manufacturing), operation without the protective housing may be necessary. In these cases, the Laser Safety Officer shall assess the hazard and ensure that appropriate controls are instituted. The controls may include (but are not limited to):

* Access restriction;
* Eye protection;
* Area controls;
* Barriers, shrouds, beam stops;
* Administrative and procedural controls; and
* Education and training.

***Interlocks on Protective Housing***

An interlock system which is activated when the protective housing is opened during operation and maintenance. The interlock prevents access to laser radiation above the applicable MPE.

***Service Access Panels***

Portions of the protective housing which are intended to be removed from any laser, by service personnel only and permit direct access to Class 3B or 4 laser radiation shall either: (1) be interlocked (fail-safe interlock not required), or (2) require a tool for removal and shall have an appropriate warning label on the panel.

***Key Control***

A master switch which is operated by a key, or by a coded access (such as a computer code).

***Viewing Portals and Display Screens***

All viewing portals and display screens included as an integral part of a laser or laser system shall incorporate a suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation at the viewing position at or below the applicable MPE for all conditions of operation and maintenance.

***Collecting Optics***

All collecting optics (such as lenses, telescopes, microscope, endoscopes, etc.) intended for viewing use with a laser or laser system shall incorporate suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation transmitted through the collecting optics to levels at or below the appropriate MPE, under all conditions of operation and maintenance.

***Beam Paths***

Control of the laser beam path shall be accomplished as described in the following sections:

***Fully Unenclosed Beam Path***

Where the entire beam path is unenclosed, a laser hazard analysis shall be affected to establish the NHZ if not furnished by the manufacturer.

***Limited Open Beam Path***

Where the beam path is confined by design to significantly limit the degree of accessibility of the open beam, a hazard analysis shall be effected to establish the NHZ.

***Enclosed Beam Path***

When the protective housing requirements are temporarily relaxed, such as during service, the LSO shall effect the appropriate controls. These may include a temporary area control and administrative and procedural controls.

***Remote Interlock Connector***

The remote interlock connector, such as a “Panic Button”, deactivates or reduces the accessible radiation at or below the MPE on entry to the area.

***Beam Stop or Attenuators***

The beam stop or attenuator is a device capable of preventing access to laser radiation in excess of the appropriate MPE level when the laser or laser system output is not required.

***Laser Activation Warning System***

An audible system (e.g. an alarm), a warning light (visible through protective eyewear), or a verbal “countdown” command during activation or start-up of the laser.

***Emission Delay***

A warning system which provides sufficient time prior to emission of laser radiation to allow appropriate action to be taken to avoid exposure to the laser radiation.

***Equipment Labels***

All commercial lasers are labelled. Homemade lasers, except Class 1, must have a label (with laser sunburst symbol) affixed to a conspicuous place on the laser housing or control panel.

***Area Posting Signs***

An area which contains a Class 3B or 4 laser or laser system shall be posted with the appropriate sign. A notice sign shall be posted outside a temporary laser controlled area. Signage can be obtained from the LSO.

*Sample warning sign for certain Class 3R and for Class 3B and Class 4 lasers.*

Precautionary or protective instructions

Types of lasers, emitted wavelength, maximum output and pulse duration, if applicable

Laser class

diode 20 mW Max 532 nm

***Remote Firing and Monitoring (Class 4)***

Whenever appropriate and possible, Class 4 lasers or laser systems should be controlled and monitored at a position as distant as possible from the emission portal of the laser or laser system.

# Appendix F: Administrative and Procedural Controls for Four Classes

|  |  |
| --- | --- |
| **Control Measures** | **Classification** |
| **\*Administrative and Procedural Controls** | 1 | 1M | 2 | 2M | 3R | 3B | 4 |
| Standard Operating Procedures | - | - | - | - | - | ▪ | X |
| Output Emission Limitations | - | - | - | - | LSO Determination |
| Education and Training | - | ▪ | ▪ | ▪ | ▪ | X | X |
| Authorized Personnel | - | - | - | - | - | X | X |
| Indoor Laser Controlled Area | - | ° | - | ° | - | XNHZ | XNHZ |
| Class 3B Laser Controlled Area | - | - | - | - | - | X | - |
| Class 4 Laser Controlled Area | - | - | - | - | - | - | X |
| Laser Outdoor Controls | - | ° | - | ° | - | XNHZ | XNHZ |
| Laser in Navigable Airspace | ▪ | ▪ | ▪ | ▪ | ▪ | ▪ | ▪ |
| Temporary Laser Controlled Area | - | ° | - | ° | - | XNHZ | XNHZ |
| Alignment Procedures | - | - | - | - | - | X | X |
| Spectator | - | ° | - | ° | - | ▪ | X |
| Service Personnel | LSO Determination |
| Demonstration with General Public | X | X | X | X | X | LSO Determination |
| Laser Protective Eyewear | - | - | - | - | - | X | X |
| Skin Protection | - | - | - | - | - | ▪ | ▪ |
| Protective Clothing | - | - | - | - | - | ▪ | ▪ |
| Laser Optical Fibre Systems | MPE | MPE | MPE | MPE | MPE | X | X |
| Laser Robotic/Automated Installations | - | - | - | - | - | X | X |
| Protective Windows | - | - | - | - | - | XNHZ | XNHZ |
| Protective Barriers and Curtains | - | - | - | - | - | XNHZ | XNHZ |
| Warning Signs and Labels(Design Requirements) | - | ° | ▪ | ▪ | ▪ | XNHZ | XNHZ |
| Service and Repairs | LSO Determination |
| Modifications and Laser Systems | LSO Determination |

Legend

**X** Shall ▪ Should

**-** No requirement ° May apply with use of optical aids

**MPE** Shall if MPE is exceeded ê Shall if enclosed Class 3B or Class 4

1 Applicable only to UV and IR lasers **NHZ** Nominal Hazard Zone analysis required

\* See following pages for details

## Administrative and Procedural Controls

***Standard Operating Procedures (SOPs)***

Written SOP’s shall be maintained with the laser equipment for reference by the operator, and maintenance or service personnel.

***Output Emission Limitations***

If, in the opinion of the LSO, excessive power or radiant energy is accessible during operation or maintenance of, the LSO shall take such action as required to reduce the levels of accessible power or radiant energy to that which is commensurate with the required application.

***Operator’s Training***

Education and training shall be provided for operators, maintenance or service personnel prior to the commencement of work. Refer to Education and Training section in the Laser Safety Program.

Where applicable, training shall include cardiopulmonary resuscitation (CPR) and electrical safety.

***Authorized Personnel***

Lasers shall be operated, maintained or serviced only by authorized personnel.

***Indoor Laser Controlled Area***

The following items are required for the various types of laser control areas:

***Class 3B Laser Controlled Area***

1. Posted with the appropriate warning sign(s).
2. Operated by qualified and authorized personnel.
3. Under the direct supervision of an individual knowledgeable in laser safety.
4. Located so that access to the area by spectators is limited.
5. Have any potentially hazardous beam terminated in a beam stop of an appropriate material.
6. Provide personnel within the controlled area with the appropriate eye protection if there is any possibility of viewing the direct or reflected beams.
7. Where possible, have the laser secured such that the beam path is above or below eye level of a person in any standing or seated position.
8. Have all windows, doorways, open portals, etc. from an indoor facility be either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the appropriate ocular MPE.
9. Ensure appropriate steps are available to prevent unauthorized use.

***Class 4 Laser Controlled Area***

1. Fulfill all items of Class 3B Control areas and in addition incorporate the following:
2. Personnel who enter a Class 4 controlled area shall be adequately trained, provided with the appropriate protective equipment, and follow all applicable administrative and procedural controls.
3. Fire exits and entryway shall be designed to allow both rapid egress by laser personnel at all times and admittance to the laser controlled area under emergency conditions.
4. For emergency conditions, appropriate means shall be available (e.g. “Panic Button”) for deactivating the laser or reducing the output to the appropriate MPE levels.
5. Ensure that controls are in place to prevent unexpected and unauthorized entry into the laser controlled area. These controls may be non-defeatable, defeatable or procedural as determined by the LSO following ANSI Z136.1-2022.

***Laser Outdoor Controls***

Contact the LSO for appropriate controls

***Laser in Navigable Airspace***

Contact the LSO for appropriate controls

***Temporary Laser Controlled Area***

Where removal of panels or protective housings, over-riding of protective housing interlocks, or entry into the NHZ becomes necessary (such as for service), and the accessible laser radiation exceeds the applicable MPE, a temporary laser controlled area shall be set up. This control area shall provide all safety requirements for all personnel, both within and outside the area and shall be posted outside the temporary laser controlled area to warn of the potential hazard.

***Sample Temporary Laser Controlled Area sign.***



This sign shall be posted outside a temporary controlled area, for example, during periods of service. The area outside the temporary controlled area remains Class 1, while the area within is either Class 3B or 4.

***Written Alignment Procedures***

Alignment shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of a beam, does not expose the eye to a level above the applicable MPE. Written SOP’s outlining alignment methods shall be available.

***Eye Protection***

Eye protection shall be administratively required and their use enforced when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the applicable MPE.

***Spectators***

Spectators shall not be permitted within a laser controlled area unless:

* Appropriate approval from the supervisor has been obtained,
* The degree of hazard and avoidance procedure has been explained, and
* Appropriate protective measures are taken.

***Service Personnel***

Personnel who require access to Class 3B or Class 4 lasers shall comply with appropriate control measures.

***Laser Demonstration with General Public***

LSO should be consulted for those situations where lasers are used for demonstration with the General Public.

***Laser Optical Fibre Systems***

If a disconnection of a connector results in accessible radiation in an uncontrolled area and is above the MPE the LSO should be consulted.

***Laser Robotic/Automated Installations (Class 3B and 4)***

In instances including those created by hardware failure and software errors, the laser beam from robotic delivery systems could lead to scattering. Measurements are often required to confirm the NHZ.

***Eye Protection (Class 3B and 4)***

Eye protection devices, which are specifically designed for protection against radiation from Class 3B, should, and Class 4, shall be administratively required and their use enforced when engineering or other procedural and administrative controls are inadequate to eliminate the potential exposure in excess of the MPE.

***Protective Windows (Class 3B or Class 4)***

Facility windows (exterior or interior) that are located within the NHZ of a Class 3B or Class 4 laser shall be provided with appropriate absorbing filter, scattering filter, blocking barrier, or screen which reduces any transmitted laser radiation to levels below the applicable MPE level.

***Protective Barriers and Curtains***

A blocking barrier, screen, or curtain (specifically selected to withstand direct and diffusely scattered beams) which block or filter the laser beam at the entryway should be used inside the controlled area to prevent the laser light from exiting the area at levels above the applicable MPE level.

***Skin Protection***

When working with some lasers, such as excimer lasers operating in the ultraviolet range, the use of skin protection (e.g. gloves, lab coats) are recommended. For wavelengths greater than 1.4 um, large-area exposures can cause heat loading – causing skin dryness and lead to heat stress.

***Other Protective Equipment***

Respirators, additional local exhaust ventilation, fire extinguishers, and hearing protection may be required whenever engineering controls cannot provide protection from a harmful ancillary environment.

***Warning Signs and Labels***

Warning shall conform to the required specifications and displayed in locations where they best serve to warn onlookers. Signs are available from the LSO.

***Service and Repairs***

Personnel who require access to Class 3b or Class 4 lasers shall comply with appropriate control measures.

***Modifications and Laser Systems***

The LSO may reclassify a laser, which has been modified.

# Appendix G: Registration of Lasers – Permit Application

Principal Investigator (PI) to complete this form for all the lasers under their responsibilities.

|  |  |  |  |
| --- | --- | --- | --- |
| PI Name: |  | Office Location (Building, Room #): |  |
| Phone: |  | E-mail: |  |

## Lasers in possession

#### Continuous lasers (attach additional pages as needed)

|  |
| --- |
| **Laser #1** |
| Location(s) where laser(s) is stored (Building, Room #): |  |
| Manufacturer: |  | Model: |  |
| Laser class: |  | Output maximum power (W): |  |
| Type (e.g. Diode): |  | Wavelength (nm): |  |
| Beam diameter at aperture (mm): |  | Beam Divergence (mrad): |  |
| Quantity: |  |
| Serial number(s): |  |
| Production class (commercial, home-built, modified): |  |
| Intended use (research, treatment, etc.) |  |
| Laser users: |  |
| **Laser #2** |
| Location(s) where laser(s) is stored (Building, Room #): |  |
| Manufacturer: |  | Model: |  |
| Laser class: |  | Output maximum power (W): |  |
| Type (e.g. Diode): |  | Wavelength (nm): |  |
| Beam diameter at aperture (mm): |  | Beam Divergence (mrad): |  |
| Quantity: |  |
| Serial number(s): |  |
| Production class (commercial, home-built, modified): |  |
| Intended use (research, treatment, etc.) |  |
| Laser users: |  |

#### Pulsed lasers (attach additional pages as needed)

|  |
| --- |
| **Laser #1** |
| Location(s) where laser(s) is stored (Building, Room #): |  |
| Manufacturer: |  | Model: |  |
| Type (e.g. NdYAG): |  | Wavelength (nm): |  |
| Energy per pulse (J): |  | Pulse duration (s):  | 5\*10-9 |
| Frequency of repetition: |  | Quantity: |  |
| Serial number(s): |  |
| Production class (commercial, home-built, modified): |  |
| Intended use (research, treatment, etc.) |  |
| Laser users: |  |
| Location(s) where laser(s) is stored (Building, Room #): |  |
| **Laser #2** |
| Location(s) where laser(s) is stored (Building, Room #): |  |
| Manufacturer: |  | Model: |  |
| Type (e.g. NdYAG): |  | Wavelength (nm): |  |
| Energy per pulse (J): |  | Pulse duration (s):  | 5\*10-9 |
| Frequency of repetition: |  | Quantity: |  |
| Serial number(s): |  |
| Production class (commercial, home-built, modified): |  |
| Intended use (research, treatment, etc.) |  |
| Laser users: |  |
| Location(s) where laser(s) is stored (Building, Room #): |  |

I have read and agree to abide by the regulations of the operation of lasers at York University specified in the York University Laser Safety Program.

Signature of PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: ­­­­­­­­­­­­­­­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**PLEASE RETURN COMPLETED FORM TO:** Health, Safety and Employee Well-Being,

hsewb@yorku.ca

# Appendix H: Laser Safety Permit – List of Authorized Laser Users

Issued to all Principal Investigators registered with the Laser Safety Sub-Committee.

Principal Investigator Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Contact Information: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Laser Permit Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
| **Laser User Name** | **Date of Last Training (MM/DD/YYYY)\*** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

\* Training is valid for three years. Unauthorized use of lasers or non-compliance to the York University Laser Safety Program will be subject to suspension of laser use.

\* Post a copy of this permit in the area of the laser.

# Appendix I: Emergency Contact Information

|  |  |  |
| --- | --- | --- |
| **Emergency**  | **Who to call** | **Phone number** |
| Life-threatening or medical emergencies | 911 and Campus Security | 911416-736-5333 or ext.33333 |
| Incidents/ExposureWeekdays(8:30 am – 4:30 pm) | Area Health and Safety Officer  | Faculty of Science: Director, Safety and Business Operations, 647-999-9806Faculty of Health: Manager, Health, Safety & Facilities, 416-712-2769 Faculty of Engineering: Manager, Safety & Business Operations, 437-929-2074 |
| Health, Safety and Employee Well-Being | Laser Safety Officer, 647-637-7427 or 416-736-2100 ext. 55725Alternate Laser Safety Officer, 416-220-0323General Office and on-call information: 416-436-5491 |
| Exposure/FireWeekends and after hours | Campus Security | 416-736-5333 or ext.33333 |