



Queen's University Environmental Health and Safety

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Revision: 1.0	Subject: Laser Safety	

1. Queen's University Laser Safety Program

Queen's University Health & Safety Policy requires conformance to health and safety regulations and standards. The Queen's University Laser Safety Program is provided to assist members of the university community to conform to the requirements of the Ontario Ministry of Labour , ANSI Z136.1- 1993 and related regulations and standards.

2. Application

The Laser Safety Program applies to all persons: employees, students and visitors operating or working in proximity to Class 3b or Class 4 lasers. Persons included under this program are identified as Laser Workers. All components of the program are to be completed before a laser worker starts work.

3. Program Components

a. Laser Safety Manual

This manual was produced by and is available from Queen's University Environmental Health and Safety.

b. Laser Safety Video

Every laser worker is required to view the general laser safety video.

c. Supervisor Instruction

The supervisors will ensure that laser workers have been trained in the safe operation of the laser.

d. Worker Registration

Every laser worker will complete and submit a Laser Worker Registration Form to Environmental Health and Safety.

e. Laser Inventory

An Inventory of all Class 3b and Class 4 lasers will be maintained by the Laser Safety Officer in Environmental Health and Safety.

f. Medical Surveillance

All laser workers operating or working in proximity to Class 3b or Class 4 lasers or laser systems will attend a pre-assignment and a post-assignment eye examination. Results of the examinations are maintained by the Laser Safety Officer.



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4. Laser Safety Committee

The committee is a sub-committee of the Radiation Safety Committee. The membership includes the Laser Safety Officer and a faculty or staff member with expertise in laser technology or in the assessment of laser hazards.

Duties

1. Establish and maintain policies and standards for the control of laser hazards.
2. Recommend appropriate laser safety training program materials.
3. Maintain an awareness of applicable new or revised laser safety standards.

5. Laser Safety Officer (LSO)

The Laser Safety Officer is the University Radiation Safety Officer.

Duties

1. Maintain inventory of all Class 3b and Class 4 lasers. Classify or verify classification if necessary.
2. Be responsible for hazard evaluation of laser work areas, including the establishment of Nominal Hazard Zones.
3. Approve standard operating procedures, alignment procedures and other control measures.
4. Provide consultative services on evaluation and control of laser hazards and worker training programs.
5. Inspect at least annually all Class 3b and Class 4 lasers for compliance with the Queen's University Laser Safety Program. Ensure any required corrective action is taken.
6. Suspend, restrict or terminate the operation of a laser or laser system without adequate hazard controls, and advise Laser Safety Committee of such action.
7. Approve wording on area signs and equipment labels.
8. Maintain records required by various regulatory bodies. Ensure records are maintained of medical examinations and training has been provided.

6. Laser Supervisors

Laser supervisors will be responsible for the education and training requirements for laser safety, the potential laser hazards and associated control measures for all lasers under the supervisor's authority. The supervisor will be familiar with general operating procedures of lasers under their control.



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Duties

1. Complete Laser Registration form <http://www.safety.queensu.ca/laser/register.htm>
2. Ensure that laser workers have been trained in the safe operation of the lasers or laser systems.
3. Ensure that laser workers prior to operating or working in proximity to Class 3b or Class 4 lasers participate in the Laser Safety Program Training and complete the Laser Worker Registration Form.
4. Report known or suspected accidents to the Laser Safety Officer.
5. Ensure that lasers under their control are not operated or modified without approval by the Laser Safety Officer.
6. Ensure that all administrative and engineering controls are followed.
7. Ensure that Standard Operating Procedures (SOP's) are written and available to Laser Workers under their supervision.

7. Laser Workers

Duties

1. Will participate in the Laser Safety Training Course.
2. Will comply with regulations and standards prescribed by the Laser Safety Committee, Laser Safety Officer and the laser supervisor.
3. Will be familiar with standard operation procedures (SOP's) and specific safety hazards of lasers which they are operating.
4. Will not operate a Class 3b or Class 4 laser unless authorized by the laser supervisor.
5. Will report known or suspected accidents to their laser supervisor and the Laser Safety Officer.
6. Will ensure that all spectators are properly informed of and protected from all potential laser hazards.



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CONTROL MEASURES

Control measures are devised to reduce the possibility of exposure of the eye or skin to hazardous levels of laser radiation. Substitution of engineering controls with administrative controls may be done with the approval of the Laser Safety Officer (LSO). The control measures below are adapted from ANSI Z136.1-1993.

Engineering controls

Although commercial laser products manufactured in compliance with the Federal Laser Product Performance Standard will be certified by the manufacturer and will incorporate some engineering controls, the use of the additional controls outlined in this section shall be considered in order to reduce the potential for hazard associated with some applications of lasers and laser systems.

Engineering Control Measures	Laser Classification					
	1	2a	2b	3a	3b	4
(X = SHALL, O = SHOULD)						
Protective Housing	X	X	X	X	X	X
Without protective Housing	LSO shall establish controls					
Interlocks on Protective Housing				X	X	X
Service Access Panel Interlocked and Marked					X	X
Master Key Switch					O	X
Viewing Portals reduce light below MPE			X	X	X	X
Collecting Optics reduce light below MPE			X	X	X	X
NHZ Established for Open Beam Path					X	X
Remote Interlock Connector					O	X
Beam Stop or Attenuator				O	O	X
Activation Warning Signal					O	X
Emission Delay						O
Remote Firing and Monitoring						O
Classification and warning Labels	X	X	X	X	X	X
Area Posting			O	O	X	X
Laser Control Area					X	X
Laser Control Area (Repair)	X	X	X	X	X	X

Protective Housing

A protective housing is a physical barrier preventing laser radiation in excess of the MPE from exiting the laser.

Laser Use Without Protective Housing

In some circumstances operation of laser or laser systems without a protective housing may become necessary. In such cases the LSO shall determine the hazard and ensure that controls are instituted appropriate to the class of maximum accessible emission to ensure safe operation.



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These controls may include, but not be limited to:

1. Access restriction
2. Eye protection
3. Area controls
4. Barriers, shrouds, beam stops etc.
5. Administrative and procedural controls
6. Education and training

Interlocks on Removable Protective Housings

Protective housings will have an interlock system which is activated when the protective housing is opened during operation and maintenance. The interlock prevents exposure to laser radiation above the MPE.

Service Access Panels

Service access panel which are portions of the protective housing and are intended to be removed only by service personnel, permit direct access to laser radiation.

They must either:

1. Be interlocked (fail-safe interlock not required);
2. Require a tool for removal and shall have an appropriate warning label.

Master Switch

A master switch is a key or coded access (such as a computer code) required to operate the laser.

Viewing Portals and Display Screens

All viewing portals and or display screens included as an integral part of a laser 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 operations and maintenance.

Collecting Optics

All collecting optics (such as lenses, telescopes, microscopes, endoscopes, etc.) intended for viewing use with a laser 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.

Totally Unenclosed Beam Path:

Where the entire beam path is unenclosed a laser hazard analysis shall be effected by the LSO to establish the NHZ if not furnished by the manufacturer or available as part of the classification.



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Limited Open Beam Path

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

Enclosed Beam Path

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

Remote Interlock Connectors

The remote interlock connector reduces the accessible radiation below the MPE on entry to the area protected.

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 Systems:

An alarm, a warning light or a verbal "countdown" command used during activation or start-up of the laser.

Emission Delay

Emission delay provides sufficient time prior to emission of laser radiation to allow appropriate action to be taken to avoid exposure to the laser radiation.

Remote Firing and Monitoring

Remote firing and monitoring console allows the laser to be operated from a remote location, removing the operator from the hazard.

Equipment Labels

All lasers (except Class 1) shall have appropriate warning labels affixed to a conspicuous place on the laser housing or control panel.

Area Posting Signs

An area which contains a Class 3b or Class 4 laser or laser system shall be posted with the appropriate sign. A notice sign shall be posted outside a temporary laser controlled area. Only signs provided or approved by the Safety Office will be posted.



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Laser Controlled Area

The following items are required for the various types of laser control area's.

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. Have only diffuse reflective materials in or near the beam path, where feasible
7. Have personnel within the controlled area provided with the appropriate eye protection if there is any possibility of viewing the direct or reflected beams
8. Have the laser secured such that the beam path is above or below eye level of a person in any standing or seated position, except as required for medical use.
9. 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
10. Require storage or disabling (for example, removal of the key) of the laser or laser system when not in use to prevent unauthorized use.

Class 4 Laser Controlled Area

Fulfil all items of Class 3b Control areas and in addition incorporate the following.

1. Personnel who enter a Class 4 controlled area shall be adequately trained, provided with appropriate protective equipment, and follow all applicable administrative and procedural controls.
2. Class 4 area/entryway safety controls shall be designed to allow both rapid egress by laser personnel at all times and admittance to the laser controlled area under emergency conditions.
3. For emergency conditions there shall be a clearly marked "Panic Button" (remote controlled connector or equivalent device) available for deactivating the laser or reducing the output to the appropriate MPE levels.
4. Area or entryway safety controls to deactivate the laser or reduce the output to the appropriate MPE levels in the event of unexpected entry into the laser controlled area. These controls may be non-defeatable, defeatable or procedural as determined by the LSO using ANSI Z136.1-1993.

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 without and a sign shall be posted outside the temporary laser controlled area to warn of the potential hazard.

Laser Area Signs

Laser area warning signs are available from the University Safety Office .



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ADMINISTRATIVE 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. Unless otherwise specified, administrative and procedural controls shall apply only to Class 3b and Class 4 lasers or laser systems.

Administrative Controls (X = SHALL, O = SHOULD)	Laser Classification					
	1	2a	2b	3a	3b	4
Written Standard Operating Procedures					X	X
Excessive Output	LSO Determination					
Operator Training					X	X
Serviced by Authorized Personnel					X	X
Written Alignment Procedures			X	X	X	X
Eye Protection					X	X
Skin Protection if MPE for skin exceeded					X	X
Spectator Control					O	X
Warning Signs					X	X
Modification of laser	LSO Determination					

Standard Operating Procedures (SOP's)

Written SOP's are approved by the LSO and 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 and maintenance, 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.

Education and Training:

Education and training shall be provided for operators, maintenance or service personnel.

Authorized Personnel

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

Alignment Procedures

Alignment of laser optical systems (mirrors, lenses, beam deflectors, etc.) 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. Procedures outlining alignment methods are to be approved by the LSO.



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Eye Protection

Eye protection is to be worn when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the application MPE.

Spectators

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

1. Appropriate supervisory approval has been obtained
2. The degree of hazard and avoidance procedure has been explained
3. Appropriate protective measures are taken

PERSONAL PROTECTIVE EQUIPMENT

Laser Protective Eyewear Requirements

1. Laser Protective eyewear is to be available and worn in by all personnel within the Nominal Hazard Zone (NHZ) of Class 3 b and Class 4 lasers where the exposures above the Maximum Permissible Exposure (MPE) can occur. The attenuation factor (optical density) of the laser protective eyewear at each laser wavelength shall be specified by the Laser Safety Officer (LSO). All laser protective eyewear shall be clearly labelled with the optical density and the wavelength for which protection is afforded.
2. Laser protective eyewear shall be inspected for damage prior to use.

The use of beam attenuators to align visible lasers will reduce laser beam intensities to a level that will allow the operator to align the beam without personal protective equipment. Laser alignment cards for Ultraviolet and Infrared radiation allow operators to locate the beam during alignment procedures.

Laser Worker Check List

1. View Laser Safety video
2. Review Laser Safety manual
3. Contact Laser Safety Officer to arrange a pre employment eye exam
4. Review written standard operation procedures (SOP) for the particular laser(s) that you will be working with. The SOP will also contain the Nominal Hazard Zone (NHZ) type of Personal Protective Equipment (PPE) such as eye protection.
5. Complete a Laser Worker Registration Form and send copy to Environmental Health and Safety.

LASER CLASSIFICATION

All lasers are classified by the manufacturer and labeled with the appropriate warning labels. Any modification of an existing laser or an unclassified laser must be classified by the Laser Safety Officer prior to use. The following criteria are used to classify lasers:

1. **Wavelength** If the laser is designed to emit multiple wavelengths the classification is based on the most hazardous wavelength.
2. For continuous wave (CW) or repetitively pulsed lasers the **average power** output (Watts) and **limiting exposure time** inherent in the design are considered.
3. For pulsed lasers the **total energy per pulse** (Joule), **pulse duration**, **pulse repetition frequency** and **emergent beam radiant exposure** are considered.

Class 1 Lasers

These are lasers that are not hazardous for continuous viewing or are designed in such a way that prevent human access to laser radiation. These consist of low power lasers or higher power embedded lasers. (i.e. laser printers)

Class 2 Visible Lasers (400 to 700 nm)

Lasers emitting visible light which because of normal human aversion responses, do not normally present a hazard, but would if viewed directly for extended periods of time. (like many conventional light sources)

Class 2A Visible Lasers (400 to 700 nm)

Lasers emitting visible light not intended for viewing, and under normal operating conditions would not produce a injury to the eye if viewed directly for less than 1000 seconds. (i.e. bar code scanners)

Class 3a Lasers

Lasers that normally would not cause injury to the eye if viewed momentarily but would present a hazard if viewed using collecting optics (fibre optics loupe or telescope).

Class 3b Lasers

Lasers that present an eye and skin hazard if viewed directly. This includes both intrabeam viewing and specular reflections. Class 3b lasers do not produce a hazardous diffuse reflection except when viewed at close proximity.

Class 4 Lasers

Lasers that present an eye hazard from direct, specular and diffuse reflections. In addition such lasers may be fire hazards and produce skin burns.

LASER WORKER REGISTRATION FORM

The undersigned worker will participate in the Queen’s University Laser Safety Program

Laser Video

The undersigned has viewed and is familiar with the Laser Safety Video.

Laser Manual

The undersigned has read and is familiar with the contents of the Queen’s University Laser Safety Manual.

Standard Operating Procedures

The undersigned has read and is familiar with the contents of the Standard Operation Procedures for the laser(s) listed below.

Personal Protective Equipment

The undersigned has the personal protective equipment described in the SOP available to them and is familiar with their care and use.

Ophthalmic Examination

The undersigned has completed an Ophthalmic examination.

Description of Laser(s)

Location _____

Manufacturer _____ Model _____ Class _____

Manufacturer _____ Model _____ Class _____

Manufacturer _____ Model _____ Class _____

Supervisor _____ Signature _____

Worker _____ Signature _____

Date _____

Please return the completed form to:

John Bullock
 Radiation and Laser Safety Officer
 Environmental Health and Safety
 Rideau Building